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(re)Learning to Question: Curriculum Studies and (re)Thinking Science for the 21st Century

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(RE)LEARNING TO QUESTION: CURRICULUM STUDIES AND (RE)THINKING

SCIENCE FOR THE 21ST CENTURY

by

ANTHONY JEROME STAWIERY

(Under the Direction of John A. Weaver)

ABSTRACT

This dissertation proposes a science literacy which revisits the nature of science and how it has

fallen away from its inquiry-based roots and has become a tool for oppression and exclusion. The

epistemological roots of science begin with curiosity and questioning. Asking questions is also

foundational to democratic society. A critical science literacy emphasizes the need to question

and to remain curious. Such skills can be incorporated across multiple disciplines. Therefore, this

dissertation proposes science literacy not as a literacy in the life or physical sciences, but as a

methodology of inquiry, a skillset that nurtures curiosity and strengthens critique. By

highlighting the use of science by pseudo-experts to support institutional racism, misogyny,

voluntary ignorance, manufactured uncertainty, technological influence, and environmental

manipulation, this dissertation suggests that traditional science curriculums allow professional

science to manipulate society and exploit the seductiveness of its products on unsuspecting

consumers by not emphasizing curiosity and effective questioning. Therefore, a critical science

literacy curriculum is (re)learning to question and (re)thinks science as an emphasis towards

epistemological curiosity (Freire & Macedo, 1995), creativity, and critical thinking, allowing for

the opportunity to imagine a fair and just future so that it can one day become reality.

INDEX WORDS: Curriculum, Science, Questioning, Ignorance, Education, Creativity, Responsibility, Democracy, Science literacy

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ANTHONY JEROME STAWIERY

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M. A., Augusta State University, 2009

Ed. S., Augusta State University, 2010

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Major Professor:		John Weaver
Committee:		Daniel Chapman
		Ming Fang He
		William Schubert

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DEDICATION

For Crystal,

Like all things in my life, they are meaningless without you to experience them with. You have seen me at my darkest moments while on this journey. There has been death and tragedy, joy and laughter, worry and stress, but above all you showed me love and admiration. I am undeserving of all you give me, but you deserve everything from me and more. Your support, your *infinite* patience, and your love are what got me through this, and you will always be my reason for anything.

For Landon & Laila,

Finishing this process for the two of you is more important, exciting, and scary than anything I've experienced in my life. For your entire lives I have been working on this immense project. All you've known about me is how tirelessly I worked to write a collection of pages that you have no possible way of understanding yet. But every time I look at the two of you I felt more inspired to continue, because everything I write about in here is for you and the futures that lie ahead of you. The world is dark and dangerous, and I fear what new worlds await you. But the world can also be beautiful if you learn to see it for its compassion, its diversity, its art, its poetry, and its vastness. I write this so that perhaps one day the world can be as beautiful as the two of you.

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Finally, I would also like to thank my friends and students with whom there were countless conversations about the nature of the world, its possibilities and its perils. Each conversation got me to think deeper about who I was and who I wanted to be. Your voices are everywhere in these pages and I will never be able to give you the amount of appreciation each of you deserve.

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CHAPTER 1

FOR THE LOVE OF SCIENCE: SCIENCE LITERACY AND DEMOCRACY FOR THE

MODERN WORLD

> There is a cult of ignorance in the United States, and there has always been. The
> strain of anti-intellectualism has been a constant thread winding its way through
> our political and cultural life, nurtured by the false notion that democracy means
> that "my ignorance is just as good as your knowledge." – Isaac Asimov

I enjoy discussion with my students that gives them a voice in my classroom, arguing

both sides to fuel debate and critical thinking. I want them to understand their purpose in the

world upon graduation and instill in them an understanding of just how much they are capable

of. But I can't. Today, most teachers have heard (in one form or another), "stick to the

standards," "those are not your standards," "you are not qualified to have those discussions in the

classroom." But "qualified" is a misleading word to use in education; in the secondary-education

classroom, qualified means that I successfully completed a certification exam without any

attention given to the degree going into that exam. I can be *qualified* to teach foreign language if

I study enough first-year material and pass the certification exam, which does not mean you want

me teaching children another language. As a physics teacher, I have worked with other physics

teachers whose backgrounds are not in physics and have not taken any physics classes in their

academic careers. They did however, take a "broad field" certification exam in science and

passed, *qualifying* them to teach anything in science. I have read numerous other dissertations

and other works that have English teachers using their classroom to discuss social responsibility

through poetry, literature, or fiction. I'll argue, however, that a science classroom is just as

significant a place to have such discussions. After all, how are literature teachers any more

qualified than a science teacher to have discussions about social injustices or how your assigned

content plays a role in those injustices? Science is a driving force to the future; whether through

technology, discovery, or innovation, science has taken mankind from caves to cities, from walking to flying, from seeing the horizon to seeing other worlds, so why am I not allowed to have discussions about social injustice and responsibility in my science class? Shouldn't scientific principles be delivered in conjunction with humility? Socially-irresponsible science brings pollution, climate change, mass extinctions, weapons of mass destruction, engineered diseases, and plays critical roles in education curriculum, political agendas, and creating panic among scientifically-illiterate people, to name a few. I propose that while the humanities and liberal arts are an important curriculum, so too is a socially responsible science literacy curriculum.

I want to be clear: I write this because I have to. Not because it is expected by a committee, not because it is necessary for a piece of paper I can frame and hang on the wall, not because I'm so far in there's no point in stopping now, but because I can no longer be told that it is not my place to inform. I can no longer be complicit in a system that tracks individuals rather than empowers them. Perhaps it is fitting that this is a culminating project, one to allow me to share all of the experiences that have shaped my ability to comment on such things. Therefore, I have become convinced that scientific practices, as I have come to understand them from experience, can build an engaging democracy; a democracy where the population is well informed, challenges and questions its representatives, and does not seek profit at the expense of the many. But scientific practices must be responsible, befitting a profitable quality *of* life and not quantity *in* life. This requires more than just knowing principles in the life or physical sciences, it requires a science literacy, a knowing of how those principles affect life as opposed to simply observing its effect on life.

This science I write about is not the physics, chemistry, or biology most have come to recognize as science. Rather, I speak of science as an action or process; a pursuit of truth through dissection (of information) and analysis. But to call this process science is too misleading since the term "science" has become too saturated with individual experiences in biology, chemistry, or physics. Therefore, I will refer to the *action of* science as science literacy, arguing that literacy in science allows one to understand how to investigate situations and question the information fed to them and to also be socially conscious of the possible consequences. In science, the information is available to those who would question the nature of things, if all they would do is begin questioning.

Beginning to question however is not enough if we are not asking the *right* questions. Science literacy may provide the tools to be critical and curious, but without a foundation that is grounded in social justice, environmental consciousness, and ethical behavior then the *right* questions will be absent. Science literacy must be part of a curriculum that emphasizes the effects of information on humanity; science literacy must be a part of the humanities. Weaver (2010) argues, "Science is too important and pervasive to be left to the scientists. It is too much a part of everyone's lives for poets, literary critics, and other citizens of the world to ignore" (p. 39). There has to be a balance of skills in the world and part of the knowledge of science literacy is to know where and who to go to for reliable information and interpretation Instead, the post-literacy era is among us, where receiving information is predicated by those with a microphone and those in positions to control the narrative, and the rare thing is to independently conduct research to make conclusions. I argue that science literacy together with the humanities is strong enough to challenge such a system and has the potential to generate an informed and responsible populace in a democratic society.

There have been numerous scholars who have spoken about science and its philosophy. I do not seek to challenge their claims, correct their definitions, or regurgitate their work. Instead, I intend to discuss a science literacy that is responsible science, not a field of gaining *profitable* knowledge but an awareness of what to do with the knowledge that is gained. I argue that the focus of science literacy is not *what* knowledge is gained but simply that *a* knowledge is gained. Further, knowledge should be gained through a challenge of others' claims, through critique and an attention to motives and potential benefits rather than by a blind acceptance of a scientist's narrative. After all, according to Harding (1993), "most scientists are not in a position to evaluate in a maximally objective way important parts of the evidence that they use in arriving at their results of research" (p. 1). Scientists may be knowledgeable, but the knowledge they share is what remains after being filtered by politics, corporate interests, religious doctrines, and personal ambitions. As Cartwright (1999) argues:

> Scientists, after all, operate in a social group like any other; and what they do and what they say are affected by personal motives, professional rivalries, political pressures, and the like. They have no special lenses that allow them to see through to the structure of nature. Nor have they a special connection or a special ear that reveals to them directly the language in which the Book of Nature is written. (p. 46)

As a species that is subjected to Nature, possessing science literacy empowers the beholder to challenge the claims that attempt to categorize nature into sects of laws and practices. To speak with optimism, humanity should have symbiotic relationships in human-human interactions as well as human-Nature interactions, rather than parasitic ones. Therefore, social awareness to scientifically driven policies becomes necessary to avoid a benefit-hierarchy where only those at the top experience a profit *in* life quality and those at the bottom must bear the weight of policies

and regulation beyond their control. Such situations are unchallengeable when a large portion of the population lacks the tools to present challenge.

I suppose my attraction towards responsible science comes from two collective experiences. The first is from these last 10 years in the classroom. I have been a physics teacher for every one of those years, though my bachelor's degree is in mathematics (*qualified*?). As a college graduate, bragging about my understanding of mathematics and physics contributed to a socially accepted view of science, a field of arrogance and exclusivity. Take for instance the inception of the Royal Society as reflected on by Kitcher (2001):

> When a handful of distinguished gentlemen came together in post-Restoration England to set up the Royal Society, they agreed that membership should be open only to the better sort. Allowing tradesmen and artisans to join the collective search for truth seemed too dangerous to be tolerated, for, after all, the worldly interests of such people might corrupt their decisions about what counted as genuine knowledge. (p. 29)

This conception of science has not been altered much, as if the scientist or the claims made by them are infallible. Latour and Woolgar (1986) pose, "the work of individual scientists, or the work of scientists in general, is often understood only in a sort of magical or mystical way" (p. 13), leaving the general population to believe that only scientists can influence reality. And, although there has been continued challenge of scientific claims on issues of global warming, disease control, among others, these challenges are not necessarily built upon a lack of democratic practices to challenge scientists, but rather used as platforms for political agendas. Regardless, control of information, whether by design or not, creates an elitism in the scientific practices, supporting an accepted mentality of *you're just not good enough to participate* to the non-scientist observer. As an example, consider Weaver's (2010) argument of "Pharmaceutical

pedagogy," which "encourages people to think drugs first to solve their medical concerns and to accept their fate as helpless objects unable to solve any potential problem with their own intellect" (p. 86). Admittedly, I participated in this paradigm by portraying a mindset that because I understood science, specifically physics, I was privy to ultimate truth that superseded any other attempts at important information. Today, I see the fallacy in who I was and how I projected myself and this becoming-self-aware has been a grueling process. With each year in the classroom I looked at my abilities with less and less admiration, realizing that my knowledge did not necessarily place me either above or below any of my colleagues or even above my students in many ways. Knowledge is important, but the importance of knowledge is relative and should be appreciated in all its forms.

The other experience developed throughout my journey in curriculum studies. I had spent most of this time trying to get a clear definition of what curriculum studies really meant. I can quote some of the major players in the field and write out what they have defined it to be and while I do not dare suggest that their definitions are subjective, I was never able to take their definitions and gain an understanding from them. This changed when at a point closer to the middle of my studies a fellow classmate was sharing her idea for her dissertation topic with the group. She said she was going to write about "chairs." Odd, I thought to myself, but I learned that in such an intellectually freeing program such as curriculum studies it is not important that meaning is understood, but that you understand there is meaning. Her idea, however, stuck with me. The following week I was going through another day in the classroom when during my first period class I noticed one my students sitting in their seat with a face that could not hide the trails of tears that had been there just moments before. An hour later, a different student sat in the same chair, but this student was ecstatic for the football game after school that day. An hour

later, a new student that was upset because they had to pick up a younger sibling from their elementary school. Suddenly the concept of chairs became clear, as did the definition of curriculum studies. As an educator, if you focus on one chair in your classroom for an entire day you will be taken for quite a journey: with each new class a new body rests on that chair, while each student may be comparable in measurable weight, the *weight* of each child is significantly incomparable. If you imagine that you were the chair, you would feel this *weight* change with each child, a *weight* that includes having to work nights to support a family, or a child that is dealing with disease, loneliness, or depression, or perhaps the child is trying to remain strong and do the "right" thing by prioritizing their education while a loved one fights to survive elsewhere. In this moment, all the definitions of curriculum studies became clear; the phrase "lived experiences" became more than just social injustice and stereotypes, it became an empathetic-centered pedagogy where the curriculum of the class is dynamic, designed to satisfy the needs of any child and the *weight* they bare.

This understanding is very narrow and only represents a sliver of what I have learned in curriculum studies, but nevertheless it opened the floodgates in my mind to allow for a change in who I was as an educator, a father, a husband, and as a human-being. But I struggled to let go of my background in science, I felt that science does not have to be segregated in fields of study but can be a unifying understanding of how to approach the world, challenge the world, and better the world. For me, curriculum studies *is* the world; to engage in its field is to examine the human condition, challenge the power structures that harm the quality of life of any group, and become an educator who uses these to develop a presence in the classroom that respects who the students are, where they come from, and what they can become.

Curriculum studies has also been a terrible experience. It has made me angry with the world and has continued to do so over the last few years. For example, with each attempt at writing a new line for this dissertation, my attention is constantly interrupted by some sound bite playing somewhere (in the house, the cafe, or anywhere else I sought solitude to work) that highlights some vote on a congressional bill, or some politician blaming opposing party members for their inability to get things done, or the President of the United States using his platform to ostracize *another* group from American citizenship, or a new protest march involving either far-right or far-left groups. Each instance is blasted as an attempt to convince the listeners who is right because their microphone is loudest. I laugh, because I know better than to listen to nonsense and would rather take the time to research for my own conclusions. But I am also terrified, angered even, as I look at all those around me who have developed their understanding solely on the sound bites or through the 140-character limit of a Twitter post; even worse, "facts" are believed to only come from *one* source regardless of how unsupported or ludicrous they are: also known as "alternative facts." I have never been so mentally unfocused in my life. I want to scream at the ignorant, I want to change the world, I want to forget that I ever became aware. I feel like the character Cypher from 1999's *The Matrix* when, during a conversation with an agent of the computer-generated world, he says: "I don't want to remember nothing. Nothing!" The context of the scene is that the character, having been freed from the computer-designed world and exposed to the truth, is tired of knowing the truth and would much rather be put back into the fake world without memory of ever knowing the truth. This is where I am when it comes to the effects of curriculum studies. Curriculum studies is the red pill in *The Matrix*, a pill that awakens you to the truth. In the movie, if instead you take the blue pill you go home and continue your

life unaware that you are inside a world that has been designed (and limited) by something else. As the character says, "Why, oh why, didn't I take the blue pill?"

But, the red pill has been taken and now I am aware. My influence however, is small and will never reach the magnitude it needs to make any real change in the world. Therefore, I will start in my localized position as an educator in a science classroom. My goal then is to challenge the science curriculum that is not doing enough to solidify its importance in democratic practices, policy formation, and in the ability to engage effectively in those activities. Without critical-analytical skills, individuals fall victim to a world where power structures continue to siphon the quality of life away from the sub-elite classes in order to continue benefiting the hegemonic institutions that placed them there. Without a skillset that befits questioning, democracy fails to support its people as it strains and is forced into a distorted state where the vote is counted but the voice is silenced. Without a curriculum of (scientific-)responsibility, knowledge gained is equivalent to ignorance-of; knowledge about things is useless unless it comes with an understanding of how those things can and *should* affect others.

(Socially/Democratically) Responsible Science

In order to question the moral, social, and political implications of legislative implementation, the people must be given a skill-set to understand and challenge each aspect of the proposal. Science literacy builds these skills because it develops a thirst for answers, an understanding for the need to investigate, and the stubbornness of not being satisfied with answers unless the evidence, from multiple sources, supports the claim. Feyerabend (1982) argues, "The citizens of a democracy cannot rest content with…pious faith. Participation of laymen in fundamental decisions is therefore required *even if it should lower the success rate of the decisions*" (p. 87, emphasis included). But this is not the democracy that has institutionalized

itself into our society. Students are not given an environment in schools where issues commonly debated between political candidates can be further understood. Rather, as products of the *institutions of the corporate state*, students leave at age 18 (ideally) and have only been conditioned to believe that the *vote* is all that matters, not necessarily what the vote is for or how it will affect others. "A democracy", Feyerabend continues, "is an assembly of mature people and not a collection of sheep guided by a small clique of know-it-alls" (p. 87). If a democracy is built so all people represent the ruling class, then individual needs come second to the needs of all. However, the concept of the majority vote is dangerous in a society where one's intelligence is just as valuable as another's ignorance (see Isaac Asimov quote at the beginning of this chapter). This is the tool that fuels the corrupt democratic system. Gaining knowledge is difficult, especially when one considers which knowledge is more valuable. Therefore, the common path to being elected as a representative is to exploit this difficulty to learn and promote that you sympathize with those that struggle in school by downplaying the importance of an education. Then, when they receive their voter credentials they will return your support with votes. Further, as long as this promotion of anti-intellectualism is culturally acceptable, the majority will always be populated with its supporters, because it is easier to learn nothing than the alternative. Meanwhile, the educated population dwindles and must suffer through the policy formation and implementation that is blatantly designed to benefit the few and suppress the rest.

A true democratic society envisions all people to voice opinions and oppositions for all issues, regardless of its direct consequence on their individual lives. However, with new eligible voters entering into democratic engagement that have been fed by the propaganda machine to "get out and vote" with little-to-no understanding of what the vote means, the moral, social, and political implications of the vote are ignored. Once individuals are employed and have started a

life that suits them, politics becomes a game for others to play, and voting becomes based on party affiliation, a competition among one another that is comparable to betting on horse races. Too many people want their candidate to win not because they represent the best moral leadership but because they do not want to know they chose the loser. But this outlines a greater problem: once settled, democratic participation becomes a once-in-four-years tradition (once every two years if you're an over-achiever). It is as if the issues facing countless individuals only matter when candidates are up for reelection or vacating their positions, where in the interim issues are acknowledged with a complacent mindset of "well, what can you do? Just have to wait until next election." This makes changing (or, at the risk of being too bold, *fixing*) the system impossible. Further, Kitcher (2011) posits, "The existence of elections and of majority rule is not constitutive of democracy. Often these serve as the expression of a deeper idea, that of popular control" (p. 65). To understand the system in order to make effective change, we have to understand where "popular control" is necessary, and more importantly, why we should want it. Anti-intellectualism and complacency are too institutionalized in the *adult* world, but perhaps there is a chance to influence students to enter this world with a sense of social responsibility, a skillset to investigate matters for themselves, make informed decisions based on factual evidence rather than sermon, and want to take control of the policies that govern their lives.

Science too plays a significant role in society and should therefore be subjected to the same democratic scrutiny as other political debates. However, Feyerabend (1982) argues,

> the manner in which we accept or reject scientific ideas is radically different from democratic decision procedures. We accept scientific laws and facts, we teach them in our schools, we make them the basis of important political decisions, but without having examined them, and without having subjected them to a vote. (p. 74)

It is as if because of scientific research, public debate is skewed in favor of a political agenda that has been justified by the scientific data. Citizens are given no platform to argue whether or not the research should have occurred in the first place; odd considering most scientific research is funded by public-paid taxes. Feyerabend (2011) suggests, "the sciences are not the last authority on the use of their products, their interpretations included. Questions of reality are too important to be left to scientists" (p. 51). But scientific research is given the authority and the public are subjected to the results. Dickson (1993) warns, "despite the fact that the application of scientific results…is becoming one of the biggest single issues on the contemporary political agenda, it is an issue that is steadily being removed further and further from the domain of democratic decision making" (p. 474). Engaging in a democracy with the tools necessary to also debate scientific research is necessary for the population. "Democratizing the laboratory", Dickson continues, "would be a first step toward creating a science based on new social relations and a new ideology" (p. 474). However, inviting the general public into the laboratory is not enough if they do not understand what happens there.

Making scientific practice democratically accessible presents challenges for the effectiveness of scientific research. If the public is not scientifically literate enough to understand the benefits of certain projects, their democratic choice could impede advancement. Kitcher (2001) suggests, "The sciences seek to establish truths about nature. How the resultant knowledge is used is a matter for moral, social, and political debate, but it is intrinsically valuable for us to gain knowledge" (p. 85). Therefore, if public consensus leads scientific research to cause harm, it is not the science that needs to be addressed, but the public that needs to be educated first. An education that builds science literacy is responsible science, one that develops effective questioning and analysis to engage in democratic processes.

Dissertation Outline

In *Chapter 2: Question Everything*, I provide a brief definition of science, setting the stage for an inquiry into the role science plays in society. Beginning with the claim that the way science is understood by the majority of the population is misleading, that science is not about biology, chemistry, or physics, but an entire skillset of inquiry. The ideals of Carl Sagan are used heavily in *Chapter 2*, emphasizing his claim that you do not need to have the necessary prerequisite science training to engage in science. Everyone, then, can be a scientist; but to differentiate the scientist from the pseudo-expert requires an openness to allow its claims to be critiqued and debated. Therefore, how science operates, according to Sagan, is predicated on a set of rules that outline how science should be met with challenge and debate, much like democracy. The example of Michael Faraday is used to demonstrate how lack of training does not determine one's ability to be a scientist, so long as the rules of science are satisfied. Faraday's story highlights the possibility that everyone can engage in science. Since science is an investigation of truth, how science has intertwined with religion is also discussed in *Chapter 2*. Understanding the relationship between science and religion is important since both have tremendous influence on the decisions made by politicians and their voters. *Chapter 2* closes with a discussion of pseudoscience and how it threatens the availability of information. Writers such as Carl Sagan (1996), Sherry Seethaler (2009), Colin Russell (2000), and Ian Barbour (2000) are found throughout *Chapter 2*.

In *Chapter 3*: *Science Through a Curriculum Studies Lens*, I discuss how science, while empowering as a process of questioning and critique, can also be exploited to maintain power structures in society. *Chapter 3* introduces the capitalization of science; the process of manipulating scientific inquiries for the purposes of exploitation, profits, and hegemonic

structures. These concepts are explored through what Paul Feyerabend (2011) refers to as the tyranny of science, Sandra Harding's (1998) postcolonial science, and Nancy Cartwright's (1999) nomological machine. Each of these is discussed at length in *Chapter 3* and demonstrates how the lack of science literacy opens up power structures to grab scientific practices and manipulate them to serve their interests. *Chapter 3* also serves to complete the definition of science and set the stage to explore how science has intersected with issues facing society (Chapters 4, 5, &, 6). Writers such as Paul Feyerabend (1982, 2010, 2011) , Nancy Cartwright (1999), and Sandra Harding (1991, 1998, 2006) are relied on heavily in *Chapter 3*.

Chapter 4: Cultural science Literacy begins the analysis of how science and its capitalization have played roles in shaping the institutions that perpetuate injustices in society. *Chapter 4* demonstrates that while race and gender may be identified scientifically to categorize individuals based on phenotypical attributes, the capitalization of science uses race and gender to justify stereotypes, research credibility, resource management, and to make a blanket of *truth* for all to adhere to. By using a scientifically literate lens, I argue the use of science (although an *a priori* argument) can present a challenge to this structure by identifying more characteristics that demonstrate more in common than otherwise. This is an optimistic thought for sure, but as a tool for inquiry science allows the observer to analyze this classification of individuals and question the agendas behind their oppression. *Chapter 4* heavily utilizes the writings of Michelle Alexander (2012), Sandra Harding (1991, 1993, 1993b, 2006), Patricia Collins (2000), Donna Haraway (1989), and Evelyn Keller (1995).

In *Chapter 5: Technology and the Environment* I discuss how without science literacy, people are vulnerable to manufactured uncertainty and voluntary ignorance. These two ideas have wide-reaching affects including, healthcare, technology dependence, and environmental

destruction. *Chapter 5* highlights those situations where attention is given to individuals who use their science credentials to shift the narrative in favor of the corporations paying the bills. The Tobacco industry is a prime example of how research is funded to convince the public that smoking is safe. Humanity's dependence on technology can be considered a voluntary ignorance as consumers are too focused on acquiring the next "new-thing", unaware of how disconnected they have become from others. Technology dependence also leads to a blind faith that through technology humanity will be saved, but from what, exactly? Lastly, *Chapter 5* explores the Human/Nature dynamic and how science literacy addresses issues such as climate change and global warming. This is not an attempt to take a position for or against climate change, but to emphasize how a lack of *science* literacy allows the pseudo-expert, the manufacturers of uncertainty to construct ignorance, creating more disbelief in science and not paying attention to whose profits are being protected. *Chapter 5* is supported through works by Sherry Turkle (2011, 2016), Katherine Hayles (2012, 2017), Diane Ward (2002), Robert Proctor and Londa Schiebinger (2008), Naomi Oreskes and Erik Conway (2008), and David Michaels (2008).

In the final chapter, *Chapter 6: Inventing the Future*, I explore science literacy as curriculum, an amalgam of responsible science and the humanities. The nature of scientific inquiry must involve some level of creative and imaginative capacities. Unfortunately, these capacities are not nourished throughout schooling, but squandered. Without creativity or imagination, I argue, science literacy could not survive, and the ability to question and challenge policies disappears. Once the importance for creativity and imagination are laid out, I argue in favor of a science curriculum that takes full advantage of imagination; a science fiction curriculum. My attempt here is to suggest a place, the imagined future, where students can see a world that has become a victim of its current issues or finds a way to address them. I also

demonstrate how science fiction can engage learners in scientifically literate conversations about all the issues discussed in the preceding chapters. By questioning the possible futures of society based on the action or inaction of its peoples, this leads to an argument that favors the necessity for a critical education. I then describe why a critical education would be important to develop the skills necessary to question authority; to develop a science literacy. Finally, *Chapter 6* closes with a dream of a democratic education, one that is critical, creative, and imaginative, that together with the humanities teaches its students to dream for the future (the *far* future). I argue that if students have their creative capacities supported, they can imagine a hopeful future. It is then the job of education to give them the necessary skills to invent it. *Chapter 6* uses works from Ken Robinson (2017), Robert Harrison (2008), David Blades (2001), John Weaver (2004, 2010), Robin Roberts (1993), Constance Penley (1997), Svi Shapiro (2008), and Isiah Lavender (2011).

CHAPTER 2

QUESTION EVERYTHING: BEING CRITICAL AND CURIOUS AT ALL TIMES

> Science is more than a body of knowledge; it is a way of thinking. – Carl Sagan
>
> All this is a dream. Still examine it by a few experiments. Nothing is too wonderful to be true, if it be consistent with the laws of nature; and in such things as these, experiment is the best test to such consistency. – Michael Faraday
>
> Science literacy empowers you to know when someone else is full of shit. – Neil deGrasse Tyson

The roots of science are firmly planted throughout human history. It can be argued that these roots go even further back to pre-human eras (Feyerabend, 1982). Science begins by a simple furrow of the brow, an observation that creates curiosity, confusion, and excitement at the prospect of understanding how something works or interacts with its surroundings. Therefore, the process of science started the moment there was a consciously made effort to investigate why something happened. This essence of science is missing today. Modern science no longer thrives on the curiosity and investigative process that follows but can be categorized into two camps: a process of observing something unknown then waiting for someone else to explain the *truth* to everyone else or build on the work of previous scientists. Modern science is exclusive to scientists, or at least that is how it is perceived by the population. This is a dangerous situation in the sciences since it opens up exposure to false claims, pseudoscience, conspiracy theories, and allows science to become a propaganda machine.

All is not lost however as more scientific principles are presented to the non-scientist through diverse mainstream delivery methods. Blockbuster movies such as 2014's *Interstellar* or 2015's *The Martian*, demonstrate a few of the instances where hard science (biology, chemistry, physics) have found their way into popular culture in ways that allow people to connect with characters who are subjected to complicated scientific laws and theories but are dramatized to

help maintain interest and perhaps build an understanding. Other scientists have written books to express scientific principles in simple, every-day situations. Some have used podcasts and talk shows (both radio and television) to discuss popular culture and how science is interwoven throughout everyday experiences. But science literacy is more than exposing one's self to more scientific dialogues and texts. It is a return to the roots of scientific investigation: observing a situation then investigating its true nature or being told another's interpretation of *truth* then investigating the matter yourself to either oppose, support, or alter the *truth* as it applies to you. Right and wrong have different meanings in science literacy; being wrong does not equate to failure but expresses a need to continue investigating a matter until clear predictions can be made with accuracy. This makes the act of *prediction* a scientific idea and demonstrates how the act of science is present in everyone's life. Stock brokers *predict* financial fluctuations in the market, meteorologists *predict* weather, doctors *predict* the effects of medicine and operation, individuals engage with others and *predict* the social interaction. Each prediction is the result of multiple observations and experimentation until a pattern is identified and is then referenced in order to generate desired outcomes. Science, therefore, engages with us all.

(re)Defining Science

According to my employer's website, a visitor would find my name listed on the "Science Department's" page. If asked what I teach, should I respond "science" the follow-up question is usually "which science?" as if biology, chemistry, and physics are mutually exclusive. Ironically, science education does treat the methodological branches of data collection and inquiry as independent entities, which means that both the school's website and my own response are false; I do not teach science. Rather, I specialize in a singular approach of inquiry that consists of methods to understand the motion and dynamics of matter and energy. Further,

this study is far removed from the world and the issues it faces. Consider a discussion about Newton's Laws of Motion: Newton's Laws collectively describe the nature of matter interactions, that an object's state of motion is changed in the presence of an unbalanced force (1st law), that the change in an object's state of motion is proportional to the unbalanced force acting on it and inversely proportional to its mass (2nd law), and that when two objects interact with each other they each exert a force of the same strength on the other (3rd Law). These laws are accepted as truth (realism) regardless of where the interactions occur. Therefore, if students attempt to discuss matters of the world, the content of physics I am assigned to teach is independent of such things because they are universal and above such trivial circumstances, such as social injustices (hyperbole).

Each year I grow more uncomfortable with this acceptance. There must be something wrong with the situation that has me confined to only discuss the content of physics as it pertains to universal order and not on its abilities to affect the social climate. I understand this now, after applying what I have learned from curriculum studies in the classroom. I have realized that while physics curriculum does attempt to outline the properties of reality, it is at best a product of relativism, not realism. For example, physics may provide extensive knowledge about the processes involved in fueling a star and also predict the star's lifespan, but what relevance does this have for a group of people subjected to a malicious ruler? This example is grossly simplified, but it characterizes the necessity to revisit the intention of teaching disciplines such as biology, chemistry, and physics. If the relevance of the content is ignored, then what is the true purpose of its study? If these courses are meant to nurture problem solving, I'll argue that no amount of physics problems will prepare students to solve the problems that face them in adulthood. Would it not be more beneficial to teach students how to question the nature of the

problems presented and to use tools of inquiry to dissect the situation into parts and develop solutions based on those pieces? But to do such things would mean that I would have to teach something other than physics. My colleagues would have to teach something other than biology, chemistry, forensics, earth systems, etc. Perhaps teachers like my colleagues and myself should consider a new discipline, a field that encourages questioning, curiosity, experimentation, and analysis. I want to call this discipline science, but first I'll need to (re)define it.

Defining science requires an inquiry much like the disciplines under its umbrella. If such a task is posed, one might respond by describing the methodologies of science, perhaps may even claim that science is a body of knowledge or a way of building knowledge. Some may define science as a quest for ultimate truth through data-driven experiences and conclusions, or theoretically-based predictions. Perhaps there is truth to some of these definitions, perhaps each definition is in many aspects more similar than different. However, the thesis of this dissertation is about science literacy and therefore, I choose to refer to the etymology of science, *Scientia*, which in Latin roughly translates to "gaining knowledge." In this sense, science is not defined by the categories we are accustomed to associate it with, but rather by inquiry, the simple process of asking questions that arise from curiosity, confusion, or misconceptions. In this regard, science applies to all disciplines and experiences. Further, I argue that all individuals are born scientists. At a young age we are guided by our curiosity to the unknown: an infant will examine anything within reach; a toddler can associate shapes after trial and error; a child will play with building blocks and become curious of how tall of a tower they can build; each of these instances show this innate behavior of humanity's curiosity and pursuit to know things. Returning to such a definition is important in a landscape where rather than nurturing curiosity and experimentation students are forced to conform to a one-size-fits-all education where any deviation is considered

wrong and failure is a numerically-calculated grade and not an opportunity to learn from mistakes.

Sagan-ism Science

Carl Sagan was an American astronomer in the latter half of the twentieth century. He is most recognized as a communicator of science, having written numerous books and creating the television series COSMOS. Sagan felt science was too important to remain too inaccessible to a large amount of the population. Sagan (1996) wrote, "*Not* explaining science seems to me perverse" (p. 25). Especially in a cultural landscape that is so incredibly intertwined with scientific mediums. Sagan continues:

> We've arranged a global civilization in which most crucial elements – transportation, communications, and all other industries; agriculture, medicine, education, entertainment, protecting the environment; and even the key democratic institution of voting – profoundly depend on science and technology. We have also arranged things so that almost no one understands science and technology. This is a prescription for disaster. We might get away with it for a while, but sooner or later this combustible mixture of ignorance and power is going to blow up in our faces. (p. 26)

Sagan saw the rise in cultural ignorance as a threat to prosperity and wanted to empower people with knowledge of science by simply emphasizing the need to question and to never stop questioning. Further, knowledge gained is not something to be compared with another form of knowledge so long as it builds towards empowerment and not towards oppressiveness. However, inaccessibility of science was too formidable to be resolved with poetics, a documentary series, and numerous books written in lay-man's terms. Sagan knew this; his goal was not too *make* everyone scientists, but to reintroduce everyone to the scientist they already were.

By default, humans are arguably curious. That curiosity begins with *discovery* in childhood, evolves into *purpose* in adolescence and adulthood, and finally *meaning* as elders (Robinson, Demetre, & Litman, 2017; Sakaki, Yagi, & Murayama, 2018; Thurber, 2013). However, once children enter institutions of "learning", they are subjected to the concept of *failure* and learn quickly that being curious (*discovery*) is more punishing than it is rewarding and begin to conform to one-way-or-no-way approach to learning. As adults, what remains of curiosity shifts to *purpose* where one's curiosity is focused on self-worth, planning for the future, or perhaps engage in new experiences. But, risk has now been calculated in, whether it is risk of bodily harm, risk of wasting time, or financial risk. This makes the act of questioning too "risky" as most adults would rather have a quiet, predictable life. Upon reaching the "golden-years", the elderly shift their curiosity (if they have been fortunate enough to maintain a level of curiosity up to this point) towards the *meaning* for everything. This could involve a journey to connect to religions (or reconnect, or devote more time to), travel around the world to learn about human history, or pursue the curiosity of what comes after life. Therefore, we already possess the necessary foundation for being scientists, according to Sagan. The task, then, was to resurrect that spark.

Nurturing curiosity also emphasizes the need to maintain an open-mindset when approached with unfamiliar observations. Sagan argued for the importance of remaining open to new ideas in order for science to flourish. Sagan (1996) writes,

> Science invites us to let the facts in, even when they don't conform to our preconceptions. It counsels us to carry alternative hypotheses in our heads and see which best fit the facts. It urges on us a delicate balance between no-holds-barred openness to

new ideas, however heretical, and the most rigorous skeptical scrutiny of everything –

new ideas and established wisdom. (p. 27)

Such openness is continually threatened by subjective-power structures built to control the narrative. Whether religious-, political-, traditional-, or countless other based structures, each seeks to outline the truth in ways that when challenged, demands its participants immediately assemble to fight against such foreign thinking. Sagan approached these threats through communication, by discussing straightforward, indisputable scientific discoveries that the audience could understand without the need for extensive education on the subject. The hope was that listeners, viewers, and readers would get just enough of a tease to ask one more question, then perhaps another and so on. Eventually, these curious minds would walk away with more questions than answers, which Sagan would then urge to seek out for themselves through whichever route allowed them to probe deeper into the content. Sagan continued, "This kind of thinking is also an essential tool for a democracy in an age of change" (p. 27).

If science is an art of curiosity and questioning, then where do the disciplines of science fit in? Are fields of biology, chemistry, and physics even sciences then by the definition provided above? The answer is, it depends. If, for example, an individual says, "I am a scientist because I can *do* physics" then no. However, if the individual says, "I am a scientist because I can *use* physics" then yes. The difference here is that *do*ing physics means the individual can memorize the laws of physics and can regurgitate them to recipe-like, ideal situations where the laws are obvious. On the other hand, the individual who *use*s physics is curious about the world and uses a toolbox, called "physics", to investigate a situation where the other toolboxes (biology and chemistry) would not provide the most efficient way to develop conclusions. This understanding

of the "disciplines" of science reflects the Whewellian heuristic classification system and is a necessary component to this (re)definition of science.

William Whewell was a student of many things, but he is primarily referenced as a theologian and historian of science (Sandoz, 2016; Wilson, 2011). According to Wilson (2011), Whewell is credited with the first recorded use of the word "scientist" (p. 344) as a means to summarize what was then referred to as a "natural philosopher". Quinn (2016) highlights that Whewell's historical science study was focused on "causal reasoning in reconstructing the past" (p. 11). Through this work, he developed a way to explain the meaning of science through a categorical structure, which made the "natural philosopher" an obsolete label since Whewell felt that natural philosophy was too narrow to describe his broader system of science, thus the new terminology of "scientist". But the importance of Whewell's work in science, his heuristic classification system, is the ideal representation of the science described in this chapter. Sandoz (2016) writes,

> Indeed, science is primarily defined as a quest for truth, involving a methodological framework intended to lead to discovery. As a result, compartmentalizing science in subfields boils down to the systematization of its heuristic 'processes'. For that purpose, it is not the objects studied by each science but rather the *procedures* they use, that must be distributed amongst categories. (p. 51)

The Whewellian philosophy of science, and its heuristic categorizations were meant to hold science as a singular entity built by multiple disciplines, which use different methods of observation and analysis. Consider again the example above about whether or not physics can be considered science: acknowledging a Whewellian-like classification system says that physics is not a science, but rather a collection of procedures that allow one to do science. Whether by

design or accident, this explains the current nomenclature used when describing the work of physicists, chemists, biologists, astronomers, cosmologists, geologists, meteorologists, zoologists, botanists, etc. In each instance, the resulting work is credited to a certain classification of science, but, arguably, this is not equated to each being a scientist that pursues knowledge, but profit potential instead. (re)Defining science in this way allows for a more open, engaging discipline, where curiosity is the only requirement to begin the journey of becoming a scientist.

The Rules of Sagan-ism Science

To prevent this (re)definition of science from becoming too idealistic, there must be an acknowledgement to the rules that makes science efficient at providing results while also allowing for more questions. Sagan (1996) posits, "One of the reasons for [science's] success is that science has built-in, error-correcting machinery at its very heart" (p. 27). Therefore, while arguing that science is open for all to engage in (all you need is curiosity), the process of science still requires others to participate in a dialogue about the observations, the methods of data collection and analysis, and the resulting conclusions. In this sense, science is a democratic process, if done properly. Unfortunately, too much science today occurs in closed laboratories and the discussions are left between individuals "better-suited" to discuss such things. But Sagan suggests "every time we exercise self-criticism, every time we test our ideas against the outside world, we are doing science" (p. 27). Therefore, so long as results are left open to criticism, and the inquirer does not stop questioning, then science does not necessarily have to be restricted to degree-holders in order to happen effectively. This also allows science – its process, criticism, and debate – to occur across multiple disciplines, defining what makes science literacy a powerful tool for societal engagement.

One rule of science, therefore, is to maintain an understanding that findings are subjective; one must be clear of that possibility. Sagan (1996) writes, "Every time a scientific paper presents a bit of data, it's accompanied by an error bar – a quiet but insistent reminder that no knowledge is complete or perfect" (pp. 27-28). Of course, in this instance Sagan is speaking of proper science as there are individuals who feel themselves superb experts that claim no uncertainty in their findings. But this is the point of this rule, acknowledging that there could be error in the results opens the investigation up for discussion and allows others to attempt the same experiment to either confirm or refute the findings, with perhaps less (or even more) error. Sagan continues, "Diversity and debate are valued. Opinions are encouraged to contend – substantively and in depth" (p. 31). Therefore, engaging in good science means you must be ready to be challenged, and you must be open to that challenge and willing to change what you thought was a conclusion to inconclusive results and take the criticism as the launch pad for what questions await asking.

Ultimately, whatever is determined through scientific inquiry must be shared. Consider this another rule of science. Withholding information, data, or results impedes others from continuing the investigation or participating in the necessary discussions about the inquiry. Sagan (1996) writes, "Science thrives on, indeed requires, the free exchange of ideas; its values are antithetical to secrecy" (p. 38). The openness of science, described earlier, applies here as well; science is meant to be a process that brings people together in the spirit of exploration and curiosity but is too influenced by traditional views and teachings to effectively achieve this. Most of the work done by scientists today violate this rule since their published work is typically restricted to prestigious journals that are seldom available to the public. Access to scientific information is typically found in textbooks and media, both of which are subject to agenda-

filters. Therefore, to engage in this (re)definition of science, the individual must follow these rules: be transparent about the work they are doing, identify a clear process, and share the results with any interested parties. There is so much to say about the contrast between today's science and the science presented here, but I'll save that discussion for the next chapter.

Everyone is a Scientist

Based on the rules outlined above, and the (re)definition of science earlier, I'll reiterate the claim that everyone is a scientist; all it takes is a little curiosity to get started. Even though I argued the reasons why I am not defined as a science teacher, I use this everyone-is-a-scientist claim with my students, especially when they plead that they are "not good at it." I like to use the story of Michael Faraday to counter their argument. Michael Faraday is known in the scientific community as a great thinker and experimenter and developed the understanding of electric and magnetic fields as they are known today. Because of his work, later physicists were able to unify the theories of electricity and magnetism and were also able to prove that light was a wave of interconnected electric and magnetic fields. More intriguing is that Faraday was not an ideal candidate to begin a career as a scientist, especially not a scientist with such a monumental admiration.

Faraday's family, not long after his birth, had moved to London from his ancestry home that was "in a place so remote and insignificant that none of their new metropolitan neighbors would even have heard of it" (Russell, 2000, p. 16). Faraday's family was poor and struggled for food and work. His family were devoted Christians, which Faraday had expressed as "a very small and despised sect of Christians known, if known at all, as Sandemanians, and our hope is founded on the faith that is in Christ" (as quoted in Russell, 2000, p. 21). The Faradays used their religion as the basis for almost everything they did, including the names of Michael and his kin.

Faraday's education was not what would have been expected of someone that would have his accomplishments later in life, which is what makes Faraday's story so interesting. Russell writes, "His formal education was sketchy at best, He once wrote: 'My education was of the most ordinary description, consisting of little more than the rudiments of reading, writing, and arithmetic at a common-day-school'" (p. 22). Some historians argue that Faraday struggled in school early on, however there is little agreement on whether or not Faraday had continued his education or left school for good.

Faraday, thinking himself fortunate for the opportunity, acquired a job as a book binder's assistant. Faraday used his employment to gain access to numerous books that filled in the gap of his lack of education. Of his experience as a book binder, Russell (2000) writes, "By great good fortune, in 1809 he lighted on a book that had just been reprinted and which was to serve as an introduction to the whole quest on which he was about to embark. Its title could not have been more appropriate: *The Improvement of the Mind*" (pp. 26-27). Over time, Faraday found new interest in science and began to think poorly of his current situation: "my desire to escape from trade, which I thought vicious and selfish, and to enter the services of Science, which I imagined made its pursuers amiable and liberal" (as quoted in Russell, 2000, p. 31). Faraday's journey into science began to take form when a series of fortunate events allowed him to attend a series of chemistry lectures *performed* by Sir Humphry Davy (being an excellent charismatic showman, Davy was prone to theatrics rather than informational lecture). Faraday took detailed notes of each lecture, including diagrams, sketches of apparatus, and outlining all experiments he had witnessed. Desperate for a chance to work in the field of science, Faraday took a chance and attempted to appeal to Davy by binding his notes from the lecture series and gifting them to

Davy. Davy was impressed and saw great potential in Faraday's ability *as a note-taker* and later hired Faraday to work for him as a lab assistant at the Royal Institution of Great Britain.

It was at the Royal Institution that Faraday achieved his greatest successes. Davy allowed Faraday the opportunity to use some of the equipment in the laboratories, but only after the other scientists had completed their work. Faraday never attempted anything new but would rather reattempt the experiments he observed other scientists conducting just to see if he could reproduce the same effects. During one consultation with numerous scientists from around Europe, Davy was presented with an experiment that involved a current-carrying wire placed in the vicinity of a compass. When current passed through the wire, the observers saw the compass needle diverge from North. None of the scientists could explain why electricity affected magnetism, but Faraday, who had watched the experiment from a distance as he was attending to other things in the laboratory, saw invisible "force-lines" that interacted with one another, causing the needle to jump. None of the scientists took Faraday seriously, but Faraday remained undeterred. Faraday kept with his invisible force lines and was able to use them to predict interactions with electric forces and magnetic forces, successfully. It is recorded that Faraday invented the first electric motor, using a magnet and electrical wire to create continuous motion, or that moving a magnet into a coil of wire created an electric current in the wire. These discoveries are arguably the greatest discoveries known to mankind, as they would spark the industrial revolution, advancing technology further in 200 years than what man could achieve in the thousands before. All it took was a little curiosity, and a never-ending string of questions to get him there. By default, Faraday was a scientist, he just needed the right environment to explore that inquisitiveness.

As Faraday gained prominence in the Royal Institution, eventually becoming its president, Faraday saw a need to improve the sharing of the Institution's science with the general public. When Faraday attended his first series of lectures, tickets were restricted to those in higher societal classes, meaning if the series of events that led to a wealthy aristocrat giving a ticket to Faraday's bookbinding boss who in turn awarded to Faraday, he may never have had the chance to leave the business of trade. So, Faraday wished to open the exposure of science to everyone eager to learn and began a series of Christmas lectures to do so. Ironically, the Royal Institution was established in 1799 with the "intention of spreading scientific knowledge among all social classes. That philanthropic vision faded rapidly as Humphry Davy's famous discourses attracted the elite of London society" (footnote, Russell, 2000, p. 34). Therefore, Faraday began another kind of revolution that led to the work of Carl Sagan, a voyage to share science with everyone, regardless of circumstance or means.

Faraday represents what I believe to be the epitome of access to the (re)definition of science: open, accessible, and allows for the exchange of ideas and discourse for anyone. Faraday's lack of formal education can be seen as a hindrance to possible accomplishments, but it was this lack of education that allowed Faraday to nurture an equally powerful trait. His curiosity and constant questioning led to profound ideas that others, with formal educations, could then make connections with mathematics and provide formal theories and quantitative analyses. Therefore, being a scientist is not a skill to be acquired, but rather a curiosity to be nurtured and supported. Imagination is imperative to the success of science (Sagan, 1996, p. 27), and should therefore not be stunted by conformity or traditions.

(Religious)Traditions and Science

Conformity and traditions have intersected with science throughout history. In one obvious example, the traditions and institutions of control brought on by organized religion has provided an almost routine interaction with science. Religion, for many, offers an alternative path to truth and understanding. Early historical references to religion showed it as a dominating institution that held sway over intellectual advancement in many different cultures. For this reason, science and religion have been perceived as competing bodies. Barbour (2000) writes: "Today the popular image of 'the warfare of science and religion' is perpetuated by the media, for whom a controversy is more dramatic than the subtler and discriminating positions between the extremes of scientific materialism and biblical literalism" (p. 10). Throughout most of history the dance between science and religion has been more about authority and control, not so much about which is right, and which is wrong. Here I will provide a brief discussion about the interactions between science and religion, to develop better understanding of how the two have been in constant flux with one another.

In Barbour's (2000) book, *When Science Meets Religion: Enemies, Strangers, or Partners?*, the reader is taken through numerous historically significant scientific discoveries and discusses how religious structures of the era participated in those discoveries. According to Barbour, "Science alone is objective, open-minded, universal, cumulative, and progressive. Religious traditions, by contrast, are said to be subjective, closed-minded, parochial, uncritical, and resistant to change" (p. 13). This is hardly a claim to argue in favor of one system over another. In Barbour's view, science probes the "how's" of the universe while religion asks the "why's". Barbour writes, "Belief in God is primarily a commitment to a way of life in response to distinctive kinds of religious experience in communities formed by historic traditions; *it is not*

a substitute for scientific research" (p. 14, emphasis added). Through this contrast, Barbour sums up the interchange between science and religion into four categories: *Conflict*, *Independence*, *Dialogue*, and *Integration*. These four variances allow a categorization of events that show how science and religion have addressed a given situation within the same plane.

Beginning with *Conflict*, Barbour (2000) outlines two historically significant scientific arguments that interacted with religion: the trial of Galileo, and Darwin's evolution theory. In the case of Galileo, new evidence was presented that supported the Copernican theory that argued the Earth was not at the center of the universe but rather one of multiple planets that orbit a common star. Using an altered version of spy glass technology, Galileo made the first telescope and used it to gather observations that supported Copernican theory. However, most of European culture, guided by the authority of the Roman Catholic Church, held the Ptolemaic view of the universe firm. The Ptolemaic theory suggested the earth was stationary at the center of the universe and that all planets and the Sun orbited around it. Part of the credibility to this view was that it agreed with interpretation of biblical scripture. The commonly misunderstood meaning of Galileo's trial with the church was that he simply offered a view of the universe that the church did not like. However, it was not the suggestion of new understanding that caused trouble with the church; according to Barbour, "in the end the crucial factor was [Galileo's] challenge to the authority of the church" (p. 7).

As with many individuals credited with major scientific contributions, Galileo was a devout Catholic and had no intentions of disproving religion or its doctrine. The *Conflict* of Galileo's trail came in the form of demonstrating how observations can come in direct conflict

with biblical scripture. Barbour (2000) writes:

> [Galileo] said that we should accept a literal interpretation of scripture unless a scientific theory that conflicts with it can be *irrefutably* demonstrated. He overstated the scientific certainty he could provide at a time when there was still considerable disagreement among astronomers. Moreover, the Catholic hierarchy felt under threat from the Protestant Reformation and was eager to reassert its authority. Some of the cardinals were sympathetic to Galileo's views, but the pope and several politically powerful cardinals were not. So, he was finally condemned as much for disobeying the church as for questioning biblical literalism. (p. 8)

For *Conflict*, then, science and religion must be at a juncture where the two are in complete disagreement with one another.

From this point of view, consider the case of Darwin's theory of evolution. Barbour (2000) specifies three ways in which evolutionary theory directly conflicts with religious doctrine. First, the idea that evolutionary change occurs over very long periods of time is in direct conflict with the biblical literalism of the seven days of creation. Second, evolution theory suggests that humans are part of nature whose ancestral roots can be traced back to the same starting points as other creatures. This idea directly conflicts with the religious claim that humans are made in the image of God and therefore stand apart from the rest of nature. Finally, religion argues that the universe and all its constituents had to be designed, intelligently, in order for all of it to exist the way it does. The theory of evolution, however, argues that adaptation occurs out of necessity and that natural selection will guide the evolution of species. (pp. 8-10). In the examples of Galileo and Darwin, science disagrees with religious doctrine, creating conflict

between the two bodies that do not struggle for right and wrong but rather over which has the authority to be right or wrong.

As the label suggests, the *Independence* grouping argues that science and religion are separate entities, addressing different sides of the same coin. Consider evolution as an example: where earlier Darwin's evolution was used to outline *Conflict*, the functions of science and religion can also be independent, non-conflicting approaches to evolution. From the point-of-view of science, evolution is a long, observable process of mutations that eventually become normal in a population. From religion's point-of-view, the evolution of man is simply the work of God on a time scale too immense to comprehend for us, but instantaneous to God. Another example of *Independence* can be seen in Galileo's work where he insisted that religion provided guidance for one's life, but not answers to observable reality. Galileo quoted Cardinal Caesar Baronius in a letter he wrote to harmonize Copernican Theory with Catholic doctrine saying, "The intention of the Holy Ghost is to teach us how one goes to heaven, not how heaven goes" (Barbour, 2000, p. 8). Further, Barbour posits, "[Galileo] held that we can learn from two sources, the Book of Nature and the Book of Scripture – both of which come from God and therefore cannot conflict with each other" (p. 8). Barbour also argues that the independence of science and religion can be understood if taken as differing languages: "An alternative way of separating science and religion is to interpret them as languages that are unrelated because their functions are totally different" (p. 19). However, Barbour admits that the *Independence* enterprise, although providing little conflict between science and religion, completely disregards any possibility for there to be a unified approach between the two.

Barbour's *Dialogue* approach allows for a constructive relationship between science and religion; at least more so than either *Conflict* or *Independence*. In the *Dialogue* relationship,

science and religion reach positions where rather than emphasizing the differences (*Independence*), similarities are identified and emphasized (Barbour, 2000, p. 23). An example of this relationship can be found when science and religion meet at the Big Bang (a cosmic event argued to be the beginning of our universe). Science is able to accurately predict the history of the universe up to a fraction of a second after the Big Bang, but science is unable to answer the questions of what banged, why it banged, or what happened before it banged. At this juncture, religion provides possible explanations, creating dialogue about the possibilities that led to the creation of the universe and the laws of nature that govern it. Barbour classifies this as *limit-questions*, or *boundary-questions*, essentially arguing that science can only go so far without a supplemental religious dialogue. However, as if in the same breath Barbour cautions, "We must be careful not to overstate the case for the role of Christian thought in the rise of science" (p. 23), acknowledging that other nations, not of Christian beliefs, contributed to the advancement of science through their own motivations, both spiritual and not.

Barbour's (2000) final classification is *Integration*, one that Barbour feels offers the most comprehensive and harmonious relationship between science and religion possible. *Integration* suggests that religious beliefs are supported by scientific observations. An example would be to conclude from the collective observational data of nature that there must be a Creator governing all of the processes. Further, religious understanding is accepted as interpretation and not literal from Scripture and that the interpretation changes based on scientific evidence of reality. Barbour references the eye as an example of *Integration*, paraphrasing Isaac Newton's claim, "the eye could not have been contrived without skill in optics" (p. 28). Post-Darwin scientists would argue that the eye is the result of millions of years of adaptations and mutations, ultimately leading to the eye we use today. However, Darwin actually argued that "God did not

design the particular details of individual species but designed the laws of the evolutionary processes through which the species were formed, leaving the details to chance" (p. 29). Hence, divine influence is ever present, but that does not mean investigation should be limited in understanding the truth.

In terms of modern discourses between science and religion, it would seem that science tends to be portrayed as defending the *Conflict* or *Independent* understandings, while religion attempts to argue in favor of *Dialogue* and *Integration* relationships. Barbour (2000), quoting Pope John Paul II, "Science can purify religion from error and superstition; religion can purify science from idolatry and false absolutes. Each can draw the other into a wider world, a world in which both can flourish" (p. 17). But a lack of science literacy, on both sides, narrows the world into smaller sub groups of theologies that are ultimately portrayed in conflict with one another. I came across a phrase one day with an unidentified source that said: "A scientist will read dozens of books in his lifetime and think they have more to learn. A religious person reads one book and thinks they know it all." While amusing, I argue that the same can be said in reverse of some scientists who bet all their cards on scientism and the scientific method (discussed further in the next chapter). Therefore, when observing the relationship between science and religion, one needs a science literacy, on both sides, to ask appropriate questions to probe the other for explanations that go beyond the understanding each started with.

Pseudoscience and Science Illiteracy

When considering extremes, anything can be dangerous. In the case of religion, an extreme belief that faith in God will heal instead of a scientifically proven medicine endangers life. Regarding science, extreme belief in scientific approaches can close one off to the affects research has on life (consider Henrietta Lacks and, separately, the Tuskegee Study as examples).

Arguably the greatest danger to intellectual development is pseudoscience. Pseudoscience simply allows the perpetuation of lies until they become truths. Pseudoscience is further propagated by science illiteracy, as well as access to communication technologies that allow for opinions to be read by large conglomerates of people (such as social media). Consider, for example, the simple process of "sharing" a post on a social media platform such as Facebook. While scrolling through my news feed, which shows things posted by my "friends", I may stumble across a picture I find significant in some way. If I feel that the picture supports my particular view of a given debate I can simply click on the "share" button and any of my "friends" may be inspired to do the same. After enough people have shared the picture, a "truth" emerges. However, the picture could have been altered or taken out of context and I have therefore participated in the spreading of false information. My lack of science literacy made me ignorant and naïve of the subject and simply because the image *agreed* with my *opinion*, I treated it as truth and perpetuated the lie. This propagation of pseudoscience is not new and stems from public skepticism of the authority of scientific knowledge, primarily perpetuated by skeptics in positions that are likely to benefit from public skepticism. Kitcher (2011) posits,

> In recent decades…a variety of challenges to particular scientific judgments has fostered a far more ambivalent attitude to the authority of the natural sciences. Many Americans do not believe contemporary evolutionary theory offers a correct account of the history of life. Europeans are skeptical about scientific endorsements of the harmlessness of genetically modified organisms. Around the world, serious attention to problems of climate change is hampered by suspicions that the alleged "expert consensus" is premature and unreliable. The optimistic legacy of the Enlightenment is increasingly called into question. (p. 15)

This is science illiteracy, lacking a skillset to question information and develop firm conclusions before possibly spreading false information. Pseudoscience, like false information, thrives on science illiteracy and must be addressed.

Carl Sagan (1996) feared the growth of pseudoscience throughout many aspects of human engagement. From science to economics, Sagan argues that without a science literacy, pseudoscience flourishes since it tends to provide simple, non-technical explanations. This makes it easy to understand and share with others from a position of knowing. Pseudoscience is further perpetuated by the media since it usually provides an entertaining version of an otherwise mundane truth. Seethaler (2009) references "pseudosymmetry of scientific authority", which she describes as situations where "the media sometimes presents controversy as if scientists are evenly divided between two points of view, when one of the points of view is held by a large majority of the scientific community" (p. 16). This confusion allows the more readily understood version of the truth to be more acceptable, and the more understood version tends to be so incredibly simplified that its easier for the scientifically illiterate populace to rally behind.

Pseudoscience, however, is a direct result of scientific practice. Sagan (1996) suggests, "The scientific way of thinking is at once imaginative and disciplined. This is central to its success" (p. 27). But being "imaginative" allows for the speculation of what could be considered pseudoscience. Therefore, it is not necessary to completely dismiss pseudoscience, but rather it should be used as an exercise in science literacy. What pseudoscience lacks, and is ultimately its greatest weakness, is its inability to incorporate any *error-correcting machinery*. Sagan explains

the reason science works so well is partly that built-in error-correcting machinery…The openness to new ideas, combined with the most rigorous, skeptical scrutiny of all ideas,

sifts the wheat from the chaff. It makes no difference how smart, august, or beloved you

are. You must prove your case in the face of determined, expert criticism. (p. 31)

Pseudoscience, however, is rarely challenged. It is often accepted the moment it is shared

because it is too satisfying in its justification towards one's opinions, regardless of the level of

truth that comes with it. This helps in justifying the need for the basic skill of effective

questioning, to promote scrutiny and debate over issues, demanding evidence to support an

assertion that is itself verifiable by experts. Pseudoscience is an admirable threat to science

literacy, but it can be challenged, so long as we question everything, and never stop doing so.

Seethaler (2009) cautions against the "pseudo expert", which leads to perpetuation of

pseudoscience. Seethaler posits, "Anyone who claims to have expertise about an issue but does

not have the relevant credentials is a pseudo expert" (p. 148). The pseudo-expert is a scientist,

like any other, but only if their claims are unavailable for critique and debate. If pseudo-experts

seek protection from critique by remaining behind a camera or microphone then they voluntarily

give up their credibility to be considered a scientist. We are exposed to pseudo-experts through

almost any form of information broadcasting available. Consider news shows that invite panels

of "experts" to discuss issues in popular culture. There may be some legitimate experts on the

panel, but there are also celebrity guests, athletes, political whistle blowers, and many others who

can easily sway the opinions of the audience simply because of their star status. I find myself

asking out-loud during such discussions, "what business does [insert celebrity name here] have

participating in this debate?" Unfortunately, there are more people who feel that the guest was an

appropriate member of a discussion whose theme agreed with their politics.

We see these "experts" everywhere, but it is not just celebrities that can perpetuate the

lie. Victims, witnesses, and "the masses" are also possible pseudo experts, according to Seethaler

(2009). The "victims" category includes those that have been portrayed and supported in the claim that they were victimized by something or someone. They are a powerful tool to spread information because they "tug at our heartstrings", Seethaler writes, "but that is not a reason to avoid thinking critically about the claims they present as science" (p. 147). The antivaccination community falls into this camp. One popular argument of theirs' is that vaccines cause autism, a claim with no supportive evidence from any reputable medical institution. Yet, because parents of children with autism claimed that their child's situation was caused by vaccination, groups portray these families as victims and celebrate them in ways that are convincing of the problem. What these groups do not do is seek out the support of those with relevant expertise to weigh in on the issue. A common avenue of purported support comes from the presented fact that "doctors" have agreed that vaccinations can lead to autism. What is missing from these expert's credentials is what their doctorate is in. A name flashed across the screen with the distinction of "Ph.D." or "M.D." is highly misleading since a person with a Ph.D. in Astrophysics has no place discussing the intersection of vaccinations and autism diagnoses. But they are "doctors" and that is good enough. Seethaler warns, "Be careful not to lose your willingness to be critical just because you hear someone introduced as Dr. so and so" (p. 148). Science literacy promotes the challenging of experts regardless of whether or not they have the relevant credentials, because legitimate experts will entertain questions to help eliminate pseudo facts and pseudo claims. Seethaler continues, "Legitimate experts are usually cautious about claiming authority outside their area of expertise" (p. 148), and therefore should be continually challenged to demonstrate that they are the relevant authority in the concerning argument.

The ultimate pseudo expert is the 'masses', according to Seethaler (2009). Strength in numbers is not something to take lightly. Seethaler posits, "The power of numbers is comforting"

(p. 147). Ads for commercial products constantly claim that "thousands of people" have already bought into the advertised product and use this to entice the viewer to be a part of this group. This form of pseudo-expert is also dangerous because it is what carries the most weight in democracy; if too many people believe a falsehood, decisions will be made in favor of it through the ballot box. With the availability of internet access and the plethora of freely available platforms to interact with large quantities of people, opinions, conspiracy theories, and pseudo-information is spread like a plague throughout our culture. Those with the science literacy to challenge such falsehoods, armed with the documented evidence to disprove the claims, are still so incredibly outnumbered that they are seen as the outliers, as the nay-sayers, as the pseudo-expert to the already pseudo-information. We must be careful bringing science literacy into the socio-political landscape, as it is similar to be the blade-wielding cavalryman approaching enemy tanks and machine guns.

Pseudoscience survives in culture because it also allows the potential for experiences that disagree with the laws of nature. Sagan (1996) considers the social view that science is too reductionist, too focused on reducing existence into a few simple laws and explanations. Arguably, there are plenty of situations in human experience that seem too complex to be reduced to governing laws, thereby labeling science as a restrictive body, not unlike religion but worshipping the book of Nature rather than Scripture. Sagan writes, "Tellingly, pseudoscience and superstition tend to recognize no constraints in Nature. Instead 'all things are possible.' They promise a limitless production budget, however often their adherents have been disappointed and betrayed" (p. 270). There is hope in the belief that experiences exist outside the laws of nature, which is intoxicating enough to hold onto. Like a person believing that playing the same numbers in the lottery will eventually pay off for them, ignoring the statistical data that shows

their prospects are no more or less certain than anyone else. The push for science literacy is not meant to diminish this hope, but to at least instill a critical thinking skillset to understand when hope is just a dream and when it is possible. I can hope to successfully complete my doctorate, but if I do not accompany that hope with a critical analysis to develop a plan to do so, then it will remain a dream, caught in a pseudo-reality.

Resistance to the reductionist view of science is not by accident. Humanity is constantly pushed towards creativity, innovation, to "reach for the stars", and to dream big. Therefore, when a field such as science is seen to set boundaries on what is possible there is a natural tendency to hold on to the impossible with hope for the contrary. Because of these limits, Sagan (1996) writes, "Reductionism seems to pay insufficient respect to the complexity of the Universe. It appears to some as a curious hybrid of arrogance and intellectual laziness" (pp. 270-271). In fact, it is the work of modern scientists to discover the few underlining principles of the universe. Physicists are looking for *unification*, the grand theory to explain all of physics and cosmology, chemists outline the fundamental elements of the universe and their properties, biologists are unlocking the genetic code of life. Scientists *are* reducing the complexity of nature to a few simple principles, argued as laws of the universe. By reducing nature to fundamental principles, however, scientists hold all the keys to understanding and experiencing existence. Scientists, and therefore science, are more than just holders of knowledge, they are holders of power. But that means I am in contradiction with myself, given that I've spent this entire chapter attempting to define science as open, welcoming, accessible, imaginative, creative, and unbounding. Is science open, fair, and accessible, or is it controlling and hegemonic? Depends on whether the question is referencing science as a tool for inquiry, or as a tool for oppressive agendas.

CHAPTER 3

SCIENCE THROUGH A CURRICULUM STUDIES LENS

> The sun, the moon and the stars would have disappeared long ago…had they happened to be within the reach of predatory human hands. – Havelock Ellis

> If you want to do evil, science provides the most powerful weapons to do evil; but equally, if you want to do good, science puts into your hands the most powerful tools to do so. – Richard Dawkins

The Capitalization of Science

This chapter serves two roles: a conclusion to the (re)definition of science towards science literacy; and an introduction to the oppressive nature of science and how it has shaped the socio-political landscape. This chapter also represents my own intellectual awakening which effectively contradicts the optimism of science described in the preceding chapters. If this book represents my journey through curriculum studies, then this chapter is what it all has led to. When I was assigned my comprehensive exam questions at the end of my coursework, I was asked not only to demonstrate how science can be a force for progress, but also to demonstrate how it is not and is something repressive and imperial. I remember a sense of complete shock and a realization that I was not prepared to demonstrate such an assertion. I probably experienced my most enlightening stretch as I wrote my response to those questions, realizing that everything I had been exposed to throughout my coursework served to understand this claim, that the science I promoted and believed in was more the problem than the solution in its current iteration. Throughout my coursework I was unable to make connections between what the courses were teaching and what I understood science to be. All the courses seemed to orbit around a central idea of power structures within cultural institutions, which to me seemed irrelevant to the sciences because I wanted to believe that science was unbiased and open for all. However, I now see that the connections between science and curriculum studies was not as

absent as I thought, and to study science within culture there must be attention given to the power structures created by science and scientific illiteracy. I will attempt to differentiate the repressiveness of science from the science I believe is essential to engage us in socio-political platforms; not just in the ways expected of us, but in the ways which empower us.

Two ways to approach science are as an action, or as a thing. The action of science was defined throughout the previous chapter: it is a process of gaining knowledge, open to all that are curious, demands a critical thinking skill set, and is open to debate. Science as a thing is a tool used to create divides, whether socially or intellectually. The action thrives on science literacy, the thing thrives on science illiteracy. For the remainder of the book, these two views of science will be written with distinctive specificity. The action will be italicized with a leading lower-case "s", even when used to begin a new sentence. The thing, like a noun, will also be italicized, but with an upper-case "S". In this sense, the capital "S" may seem metaphorical, but it is also literal: capital "S" *Science* refers to the *capitalization* (utilizing the polysemic nature of the word) of lower-case *scientific* knowledge. Since the previous chapter outlined *science*, I will spend this chapter focused on defining *Science*, and offer comparisons between the two.

The distinction between *science* and *Science* is not new. In Weaver's (2010) analysis of Mary Shelley's *Frankenstein*, Weaver argues, "Shelley offers two visions for science – the Master scientist who alters and interferes with nature and the 'scholar-scientist' who respects the power of nature and seeks to only understand" (p. 35). Here, the Master scientist represents a *Scientist*, while the Scholar scientist, a *scientist*. The act of studying nature simply to understand it is *science*; understanding nature so as to figure out ways to manipulate it is *Science*. Manipulation is not necessarily a negative thing, so long as that manipulation seeks to benefit many rather than enriching few. Dyson (2006) writes, "As a general rule…science works for evil

when its effect is to provide toys for the rich and works for good when its effect is to provide

necessities for the poor" (pp. 24-25). Effectively, *Science* produces monetary-capital while

science produces knowledge, but how that knowledge is utilized determines whether or not the

"*s*" changes.

Knowing that *science* can be "weaponized" (both literally and figuratively) is not enough

to disregard the possibilities that *science* brings to humanity. Daston and Galison (2015) write,

"Science is fertile in new ways of knowing and also productive in new norms of knowledge" (p.

41). Though the possibilities for growth in *scientific* knowledge is nearly boundless, remaining

objective in the interpretation of observations is not a simple task. Daston and Galison add,

> "Objectivity knowledge," understood as "a systematized theoretical account of how the
>
> world really is," comes as close to truth as today's timorous metaphysics will permit. But
>
> even the most fervent advocate of "objective methods" in the sciences – be those methods
>
> statistical, mechanical, numerical, or otherwise – would hesitate to claim that they
>
> guarantee the truth of a finding. (p. 51)

The scientist (not italicized, therefore not particularly representative of either *science* or *Science*)

struggles to remain objective, even if there is belief that the methods used yielded objective

results. The scientist that sketches images based on observations is *subjective* to the individual's

attention to certain details, limited also by his or her artistic abilities. Images collected from

cameras are more objective but are still *subjective* to the type of medium used, the quality of the

lens, the positioning of the camera, the angle of light interacting with the object, the length of

exposure. I have experienced this firsthand through astrophotography, where I've learned that

one telescope may see something completely different (more or less detailed) than another

telescope (among a plethora of other characteristics and settings that affect the "seeing" of astro-

observing), revealing a different truth about the observation. Further, objectivity is threatened by the intentions of the observer. The values of the sciences and the scientist are always interfering with objective methodologies. According to Feyerabend (2011):

> sciences as they present themselves today…are free of values. But that is simply not so. An experimental result or an observation becomes a scientific fact only when it is clear that it does not contain any 'subjective' elements – that it can be detached from the process that led to its announcement. This means that values play an important role in the constitution of scientific facts. (pp. 94-95)

Therefore, another distinction arises, *science* operates with a disclaimer admitting to its non-objective methods, making it clear that should another researcher conduct the experiment in the same outlined procedure similar results will follow. The *Scientist* however, argues that the observations made were objective and are therefore shielded from criticism.

The *Scientist's* argument is also intriguing since it is responsible for the spread of the exploitation of *scientific* knowledge. Interestingly, this exploitation does not differ too much from the religious authority that scientists, such as Carl Sagan, rally against. I referenced Carl Sagan in numerous ways, including "Sagan-ism science" in the previous chapter, but one of Sagan's crusades was to challenge the authority of religion by instituting his "religion", science, as more supreme. Instead of Scripture, Sagan deified "Nature" (in the capital), claiming It has ultimate authority. Hence, *Science* can be considered a religion in its own way. Kitcher (2001) posits:

> Institutionalized science comes to seem like an effective propaganda machine, serving the interests of the elite classes and imposing its doctrines, ideals, and products, on the

marginalized masses in much the way that politico-religious institutions of the past

managed so successfully. (p. 4)

Science survives on the "propaganda machine" because its doctrines exist on a plane of knowledge above the common person. "The interests, forces, propaganda and brainwashing techniques," writes Feyerabend (2010), "play a much greater role than is commonly believed in the growth of our knowledge and in the growth of science" (p. 10). Returning to Galileo and his defense of Copernican theory, Feyerabend argues that Galileo used "*propaganda*" and "*psychological tricks*". Though effective, these tools inhibited the advancement of *scientific* philosophy because, as Feyerabend writes:

they obscure the fact that the experience on which Galileo wants to base the Copernican

view is nothing but the result of his own fertile imagination, that it has been *invented*.

They obscure this fact by insinuating that the new results which emerge are known and

conceded by all and need only be called to our attention to appear as the most obvious

expression of the truth. (p. 61)

This propaganda machine mimics the spread of the Catholic Church as the dominant authority throughout European expansion. Kitcher argues, "Science (with a capital "S") is the heir of the Catholic Church and the Party" (p. 4, parenthetical clarification included), exerting its authority as the supreme pathway to knowledge, innovation, technology, and the future. Such control allows *Science* to exist outside public debate, above "checks-and-balances" accountability. Feyerabend (1982) writes, "scientists and philosophers of science act like the defenders of the One and Only Roman Church acted before them: Church doctrine is true, everything else is Pagan nonsense" (p. 73). In comparison to *Science,* the *Scientific* Method is the only way to true knowledge, everything else is pseudoscience. Further, so long as the "true knowledge" can be

exploited for profitability, be it monetary or hegemonically, *Science* becomes its own justification to rule as judge, jury, and executioner against any other *science* that may present a challenge to perceived truths, or against truths already inherent within a native culture.

The (un)*scientific Scientific* Method: Limiting Observations to Expected Results

Science's dominance is successful because it wears an armor built upon rigid, 'objective' rules to carry out investigations in ways that make the results unarguable, unless challenged by investigations that utilize similar adherence to the commandments of *Science*. However, following the rules narrates the observations rather than the phenomenon narrating observations, therefore *Science* is a cyclic enterprise if the rules are followed because it defends what has already been concluded, even if the attempt was to challenge the conclusion. This is the fallacy of the *Scientific* Method. The *Scientific* Method determines which questions are relevant to ask, therefore limiting experiences to planned observations in order to benefit an established goal, before the question was thought of. Sagan (1996) writes, "There are no forbidden questions in science, no matters too sensitive or delicate to be probed, no sacred truths" (p. 31). This is what makes *science* a challenge to the authority of *Science*: in *science*, everything is fair game for the inquisitive mind and nothing should be held back in the quest for understanding.

If *science* and a *scientific* method are so liberating and empowering, then why has the faux-objective structure of the *Scientific* Method prevailed? The answer: *scientific* illiteracy. Without an education in *scientific* vocabulary, without exposure to critical thinking, analysis, and critique, the unknown is easier to accept if it developed through an easily-understood-structure. The structure suggests objective procedures and repeatable results, which can therefore be defended even if the *scientific* literacy necessary to understand the *science* is missing.

Cartwright (1999) posits:

> The yearning for 'the system' is a powerful one; the faith that our world must be rational, well ordered through and through, plays a role where only evidence should matter. Our decisions are affected. After the evidence is in, theories that purport to be fundamental – to be able in principle to explain everything of a certain kind – often gain additional credibility just for that reason itself. (p. 17)

The rise in every cultural belief system can be attributed to this need for the world to make sense, in an ordered fashion. However, *science* challenges this notion by arguing for an open arena for debate and questioning, as well as the necessity to be open to new understandings that may not make the world ordered or rational. But this openness to ideas and understanding is not profitable and is therefore not the method taught in science classrooms. Instead, *Science* is taught as a recipe-like formulation of experimental designs that lead to results that confirm a previously established theory. Consider as an example a question on CollegeBoard's Advanced Placement Physics 1 exam: on a constructed response question, students are asked to design an experiment to measure the electric current through a resistor. The correct answer, based on the scoring rubric used to score all responses (world-wide), states that students should mention Ohm's Law (theory) and the students should produce a graph of the *expected* data that use Ohm's Law to confirm their results. In this example, the primary focus of the question is not whether or not students understand how to apply *science*, but rather how to develop an experiment to prove a result already known.

The rise of the *Scientific* Method as the law of all *Scientific* endeavors has deep roots in the history of scientific philosophy. According to Kuhn (2012), the concept of science as a ritualistic set of methods "[that have] previously been drawn…mainly from the study of finished

scientific achievements as these are recorded in the classics and, more recently, in the textbooks from which each new scientific generation learns to practice its trade" (p. 1). Kuhn continues by equating this "image" of science as comparable to expecting a foreign culture to be accurately represented in travel brochures. The science presented in textbooks is misleading, depicting science as set of procedural rules and predictable outcomes rather than an open process capable of paradigm-shifting change. Because of the *Scientific* Method, students believe that all science asks very similar questions that are only changed for relevance within the individual branches of science (such as chemistry, biology, or physics). Instead, students should be challenged to attempt to develop experiments to add to the validity of a concept, not by reproving the theory, but by asking questions not already asked and seeing if the results only work if the theory is implemented or not.

From this view, students should be taught that *science* exists in two ways: as a journey to understand more and as a method that seeks to find flaws in established theories, or to find new ways to apply established theories. One of the main postmodernist arguments against *Science* is its testament of objective, absolute truths. Cartwright (1999) challenges:

> Can we be assured that for every new situation, a model of our theory will fit at [some new] level, whether it be a model we already have, or a new one we are willing to admit into our theory in a principled way? This is a question that bears, not on the truth of the laws, but rather on their universality." (p. 48)

Returning to the "yearning" for rationality, accepting theories because they are published in textbooks relies on the assumption that enough scientists have proved the theories' universality and are therefore regarded as absolute truth. This assumption carries over to all mediums that provide information where truth is determined because it is presented to the audience without

debate, or with a panel of "experts" that were chosen specifically because they all share the same opinion. *Science*, however, refutes the postmodernist's attacks because *Science* provides evidence that points to an objective truth. Harding (1998) suggests, "the success of modern science is insured by its internal features – experimental method or scientific method…science's standards for maximizing objectivity and rationality…there is one and only one science – and its components are harmoniously integrated by such internal features" (p. 2). However, the internal features are limiting in the results they provide. Cartwright writes, "our best theories are severely limited in their scope: they apply only in situations that resemble their models, and in just the right way, where what constitutes a model is delineated by the theory itself" (p. 12). Therefore, what the *Scientific* Method teaches is that science is conducted by choosing a theory and creating an experiment that will reinforce it by *design* rather than by experiential evidence.

Choosing the right model is also a violation of the objectivity-claim of *Science* since the model is *subjectively* chosen to fit the model. Daston and Galison (2015) argue, "All science must deal with the problem of selecting and constituting 'working object,' as opposed to the too plentiful and too various natural objects…No science can do without such standardized working objects" (p. 21). To do so would introduce too many variables to the problem and the theory and the experiment fall apart, proving the dilemma that *Science* acts subjectively while claiming to operate objectively. These models, or "working objects", are "acquired through education and through subsequent exposure to the literature often without quite knowing or needing to know what characteristics have given these models the status of community paradigms" (p. 46), argues Kuhn (2012). Therefore, not only are experiments designed with desired results in mind, but the quest to validate a given theory is much more valued than the potential the theory has to affect culture. Further, as experiments build upon *Scientific* theories, the results remove the

accessibility of those theories from the common public. Kuhn posits, "Further development…ordinarily calls for the construction of elaborate equipment, the development of esoteric vocabulary and skills, and a refinement of concepts that increasingly lessens their resemblance to their usual common-sense prototypes" (p. 64). Developing *Science* is therefore a practice in expanding *scientific* illiteracy so as to position itself as the authority of what is true and how one discovers truth.

Advancing *Science* is less about new understandings and more about refinement of what is already known. *Scientific* experiments focus on reestablishing theories and call it progress. The flaw of the *Scientific* experiment is the lack of attention to the unexpected variables. According to Cartwright (1999), experiments are built "to fit the models we know work. Indeed, that is how we manage to get so much into the domain of the laws we know" (p. 28). *Scientists* gain prominence through this practice because it allows them to be perceived as working individuals who build experiments and successfully test theories. Never-mind that the experiment was built with the sole purpose of demonstrating the validity of a given theory. "Consciously or not," Kuhn (2012) writes, "the decision to employ a particular piece of apparatus and to use it in a particular way carries an assumption that only certain sorts of circumstances will arise" (p. 59). The theories of *Science* then are questionable when it comes to their universality, their credibility in their declaration of truth, and the model of the world that is built, resembling a prison to cage public involvement and intellectual flourishment. Further, the *scientifically* illiterate are subjected to adopt the model of the world built for them because they do not possess the skills to present challenge. Cartwright argues, "The problem is that our beliefs about the structure of the world go hand-in-hand with the methodologies we adopt to study it" (p. 12). These methodologies can refer to *Scientific*, religious, traditional, or cultural. However, regardless of

which methodology is used, each creates belief systems that limit the understanding of the nature of reality by adhering to set doctrines that create borders between the known and the unknown. The borders prevent intellectual development for those subjected to it because only those qualified are allowed to venture into the unknown and return with an interpretation of truth that becomes law within the doctrines.

In order to reinforce the border while simultaneously creating safe passage to the qualified individuals, *Science* has to produce consistent results so that it is continually validated in its superiority. Cartwright (1999) suggests that such production utilizes a "nomological machine", which Cartwright defines as:

> [A] fixed (enough) arrangement of components, or facts, with stable (enough) capacities
> that in the right sort of stable (enough) environment will, with repeated operation, give
> rise to the kind or regular behaviour that we represent in our scientific laws. (p. 50)

These machines allow *Science* to have ordered methodologies and factory-like production of data. However, the machines are very specific and do not account for any variable change. Cartwright adds, "nomological machines have very special structures. They require the conditions to be just right for a system to exercise its capacities in a repeatable way" (p. 73). Any anomaly in the data is disregarded as error in the experiment and not considered as a possible flaw in the theory. Feyerabend (2010) writes, "These processes carry a true picture only as long as they are left undisturbed. Disturbances create forms which are no longer identical with the shape of the objects perceived – they create *illusions*" (p. 108). These outliers, or "*illusions*" are important enough to generate new questions about the nature of experimentation and the interpretation of the collected data. But in the quest for universality, *Science* holds to its traditions and uses the abundance of agreeable data to form conjectures about the absolute truth

of the theories. The data form a shield that protects *Science* from objection and challenge. From inside the shield, "we know how to calculate what the laws will produce, but outside, it is too complicated" writes Cartwright, "If the events we study are locked together, and changes depend on the total structure rather than the arrangement of the pieces, we are likely to be very mistaken by looking at small chunks of special cases" (p. 29). Therefore, the *Scientific* Method is a process of remaining inside the box, the protective shield built upon data and assumed-objectivity, while the *scientific* method is a *science* literacy, open and outside the box searching for unexpected results or clues that indicate there is more to understand than the classics have taught us.

The sharing of collected data is a hegemonic activity on its own. Shared data is usually provided out of context to the purpose of why the data was collected at all. "When phenomena are variously reduced to data," according to Gitelman and Jackson (2013), "they are divided and classified, processes that work to obscure – or as *if* to obscure – ambiguity, conflict, and contradiction" (p. 9). With data, *Scientists* are able to control the narrative of their work and can use the results to satisfy the agenda of either themselves, or the ones providing the funding. The important thing is to know that data is *interpreted*, not precise. Whoever interprets the data writes the articles and textbooks and ultimately controls the cultural understanding of the *Science* conducted. Gitelman and Jackson continue, "given certain data, certain conclusions may be proven or argued to follow. Given other data, one would come to different arguments and conclusions" (p. 7). This discrepancy is not a challenge to the authority of *Science*, however, but rather it represents how the capitalization of *science* can be manipulated to serve a desired purpose or outcome. *Scientists*, to a degree, can then be considered *fantasy-scientists*: individuals assigned to experimentally prove an agenda even when the proof is non-existent. Feyerabend (2011) writes, "You cannot find what is not there, and if you insist that it is there, then you are

fantasizing, not doing research" (p. 93). Therefore, *Science* and its methods are arguably a fantasy-enterprise, attempting to exploit *scientific* theories to experimentally demonstrate meanings that are not there, but are desired to be.

Similar to *Science* and the *Scientific* Method, *Scientists* are not value-free and subjected to the same forces as those that drive *Science*. Kitcher (2001) posits, "All scientists believe what they want to believe. Truth has little or nothing to do with it" (p. 31). Understanding the foundations of nature allows for the formulation of experiments to use that information in an imperial way, regardless of how little it is representative of the original principles. *Scientists* are the key operators in such endeavors. Further, their attempts are meant to simplify reality down to simpler and simpler terms that can explain every situation, inhibiting curiosity and authentic experience. Feryerabend (2011) posits, "all pre-scientific evidence, conflicts with some very old and very basic scientific ideas. We have to conclude that science did not start from experience; it started by arguing against experience and it survived by regarding experience as a chimera" (p. 40). Since experience is unique to the individual, it presents a problem to the rationalized view of the world that *Science* attempts to contain. Conformity and acceptance are *Science's* tentpoles and it constantly works to reinforce its claims.

True advancement in *science* comes from unexpected results, the changing of variables not accounted for in the theory. *Science* seeks to argue that its theories are universal and forever, once a truth is discovered it remains a truth. Feyerabend (2010) outlines the process of advancing *science*:

> For example, one asks: given background knowledge, initial conditions, basic principles, accepted observations – what conclusions can we draw about a newly suggested hypothesis? The answers vary considerably…precise observations, clear principles and

well-confirmed theories *are already decisive*; that they can and must be used *here and now* to either eliminate the suggested hypothesis, or to make it acceptable, or perhaps even to prove it.

Such a procedure makes sense only if we can assume that the elements of our knowledge – the theories, the observations, the principles of our arguments – are *timeless entities* which share the same degree of perfection, are all equally accessible, and are related to each other in a way that is independent of the events that produced them. (p. 105).

Hence, the advancement of *science* is tricky because it has to fall in direct contrast with the *Science* that exists. As an example, Newton's Law of Gravitation has been a staple of physics for over two hundred years. Mathematically, Newton proved that the motion of heavenly bodies can be predicted with astounding accuracy. This achievement held as the foundation of modern science until Einstein argued that the force of gravity was not an invisible tug from one object to another but rather the warping of the fabric of space-time. Over 100 years later and scientists are still attempting to develop experiments to test the validity of Einstein's hypothesis, but not Newton's. The reason that *Science* prevails is because its process is too simplistic to truly understand the complexity of nature. With each answer a new question should be asked, but the expectation for theory production is too high to keep asking questions that may lead to undesirable results. Feyerabend continues:

[The] procedure overlooks that science is a complex and heterogenous *historical process* which contains vague and incoherent anticipations of future ideologies side by side with highly sophisticated theoretical systems and ancient and petrified forms of thought. Some of its elements are available in the form of neatly written statements while others are

submerged and become known only by contrast, by comparison with new and unusual

views. (p. 105).

Good *science* operates in the contested views of the established. It seeks to understand things that

no one thought to understand before. It seeks to change the understanding of nature by

identifying hidden realities that otherwise go unnoticed. To limit *science* to a procedure is to

limit the possibilities of intellect.

The biggest leaps in *scientific* achievement occur without a written procedural

framework. Feyerabend (1982) argues in favor of "no scientific method" by outlining

achievements throughout history. Such as Stone Age early man that was able to generate and

sustain fire without the *Scientific* method, build ocean-worthy vessels that "conflicts with

scientific ideas but is, on trial, found to be correct" (p. 104). Even the advancement in Western

medicine proved inadequate when compared to cultural traditional medicine in early twentieth

century China (p. 103). Feyerabend asserts:

The lesson to be learned is that *non-scientific ideologies*, *practices*, *theories*, *traditions*

can become powerful rivals and can reveal major shortcomings of science if only they

are given a fair chance to compete…The excellence of science, however, can be asserted

only *after* numerous comparisons with alternative points of view. (p. 103)

With all the evidence throughout history that demonstrates how curiosity and necessity advanced

science without the need for an outlined method, it is a wonder why the *Scientific* method is

given so much authority over *Scientific* processes. Feyerabend continues:

[There] is no 'scientific method', as we have seen. Thus, if science is praised because of

its achievements, then myth must be praised a hundred times more fervently because *its*

achievements were incomparably greater. The inventors of myth *started* culture while

rationalists and scientists just *changed* it, and not always for the better. (pp. 104-105)

Myth was the central inspiration behind the achievements of historic cultures, and as a muse for

curiosity it leads to developments and achievements that could not be achieved in a laboratory, or

even thought up in a procedural way. Therefore, *science* benefits from accessibility and openness

to new ideas, even mythical ones. The curiosity leads to an understanding of things that were not

even believed understandable. Good *science* is a quiet rebellion to the authoritarianism of

Science, or as Feyerabend (2010) posits, "events and developments…occurred only because

some thinkers either *decided* not to be bound by certain 'obvious' methodological rules, or

because they *unwittingly broke* them" (p. 7).

Empirical understanding of nature is revealed through a lens that is not limited to

'objective' rules of inquiry. However, understanding aspects of nature in order to capitalize on

them does follow the rules because doing so creates an image of objectivity and therefore

credibility. A *scientist* is guided by a creed that there are no forbidden questions or restricted

domains, discarding a one-methodology-fits-all *Scientific* method. Feyerabend (2010) writes:

A scientist who is interested in maximal empirical content, and who wants to understand

as many aspects of his theory as possible, will adopt a pluralistic methodology, he will

compare theories with other theories rather than with 'experience', 'data', or 'facts', and

he will try to improve rather than discard the views that appear to lose in the competition.

(p. 27)

A *scientist* always seeks to go further, making *science* an inquiry that utilizes innovation to

innovate further. That also makes the *scientist* a rebel, not willing to be restricted by the laws of

Science and its methods. A *scientist* understands, as Dyson (2006) posits, "Science flourishes

best when it uses freely all the tools at hand, unconstrained by preconceived notions of what science ought to be" (p. 17). *science* sees opportunities to further knowledge with each theory that is presented, tested, and verified. It does not want to exploit the theory to capitalize on it, it wants to apply the theory to discover new theories, utilizing newly developed tools in ways that do not fit their intended purpose. Dyson continues, "Every time we introduce a new tool, it always leads to new and unexpected discoveries, because Nature's imagination is richer than ours" (pp. 17-18). Only by embracing curiosity, imagination, and ingenuity does *science* truly separate itself from its politicized counterpart. According to Dyson, "science is a human activity, and the best way to understand it is to understand the individual human beings who practice it. Science is an art form and not a philosophical method" (p. 17).

Postcolonial *Science*

The spread of *Science* is not restricted to modern forms of information delivery. Rather, the spread of *Science* as an authority to truth and dictator of relevance within a society can be traced back to European expansion throughout the world. In a simple statement, postcolonial science represents the spread of scientific practices and principles through colonization of an indigenous culture, where the invading science is believed to be more relevant than the native science since the former was used to generate an economy. In other words, scientific advancement was fueled by the need to expand empires and bring back things of economic value. Because of this value, imperialist science replaced the science of native cultures and continued to grow and flourish so long as there was demand for its products. In this case, *Science* acquires an additional meaning: in postcolonial science studies, *Science* represents the process of developing scientific principles for the purposes of politico-economic agendas. According to

Harding (1998):

> [The] conceptual framework of postcolonial science and technology studies is organized from the standpoint of other, non-European cultures and the great masses of the world's economically and politically most vulnerable people who live in them. Their scientific and technological needs and desires are not always those of elites in the North or in their own societies. (p. 8)

Incorporating this perspective of science studies allows for dialogue from curriculum studies to enter the sciences by identifying how *Science* is used to marginalize people by restricting access to its information and using the information to establish hierarchies within the population of knowers and Others. Harding continues, "the development of modern sciences and technologies has had few beneficial and many detrimental effects" (p. 8) on marginalized people. This perspective of *Science* and the influence it has elaborates the necessity for a *scientifically* literate culture, to respectfully acknowledge the contributions, cultural influences, and similarities and differences between established *Science* and ongoing *science*. "This new kind of account," argues Harding, "does not merely add new topics to conceptual frameworks that are themselves left unchanged. Instead, it forces transformations of them" (p. 8). Growing *science* literacy is not an attempt to overthrow *Science* or abolish its practices entirely, but rather to equip citizens with the necessary tools to engage in the debate of *Science* and *science* and effectively transform the landscape of science, technology, and access to information.

From the postcolonial framework, the advancement of *science* should be influenced by the needs of the culture most vulnerable to its effects. However, this is not always the case. Harding (1998) writes, "Of course, society and the institutions, cultures and practices of the sciences should be understood to provide the necessary conditions for sciences to do their work,

but they should not influence the results of research in any culturally distinctive way" (p. 3). At its core, science is believed to be an objective exercise, but as I have demonstrated already, objectivity is more a perception than a reality. *Science* and its *Scientists* are not free of personal ambitions and agendas, which therefore produces results that do influence the culture within its web. Harding argues, "Any and all social values and interests that might initially get into the results of scientific research should be firmly weeded out as soon as possible through subsequent critical vigilance" (p. 3). Naturally, this is a difficult task to accomplish when *science* literacy is in abundance. This allows for cultures unequipped to challenge strong *Scientific* authority to become victims of its dominance and are then left to exist within the world created for them.

Currently, American democracy is subjected to a world built on capitalistic tendencies where its citizens are in constant belief that value and ownership are the most essential things needed for survival and democratic engagement. Innovation and curiosity are not nourished traits in this way of life because they are rebellious acts against a state that depends on the working-class to maintain its socio-economic structures. Individuals such as Michael Faraday would likely not exist today or have the opportunities to flourish their curiosity as he did (although the society Faraday grew up in did not necessary grant him opportunities either). Throughout history, leading *Science* has been pushed by the prospects of economic growth, not curiosity. Haraway (1989) posits, "The association of the leading corporations of the industrial world with science is not new…well before industrial capitalism, science and the commodification of the world grew up together" (p. 135). Corporations needed *Science* to expand their empire and *Scientists* needed corporate funding to continue working. This symbiotic relationship thrives so long as the population remains complicit. Mirowski (2013) suggests, "The corporate sway over science bore many other consequences for public attitudes toward science and scientists'

attitudes toward the public" (p. 147). The predominantly *scientifically* illiterate culture creates a desirable audience for *Scientists*, since the audience lacks any skills to hinder its advancement, and also creates a cultural perception of *Scientists* that they are the keepers of truth. A population with *scientific* literacy would be able to remind *Scientists* that nature governs the laws of *science*; not the laws of *Science* governing nature.

Establishing *scientific* principles are a way to understand the relationship between nature and humanity. *Science*, on the other hand, seeks to manipulate nature for benefits and rewards. This is not entirely a negative action, so long as the benefits are accessible equally among different social classes. This is what the postcolonial science studies, according to Harding (1998), seeks to identify. Harding writes, "it is not 'man' whom sciences enable to make better use of nature's resources, but only those already advantageously positioned in social hierarchies" (p. 60). Therefore, *Science* is a way to exploit nature to justify social injustices and segregations, since the aspects of nature studied by *Scientists* are already owned by the elite. Harding continues,

> It is such groups that already own and control both nature, in the form of land with its forests, water, plants, animals, and minerals, and the means to extract and process such resources. Moreover, these people are the ones who are in a position to decide "what to produce, how to produce it, what resources to use up to produce, and what technology to use." (p. 60)

Such control, if unchallenged, creates hegemonic structures that not only determine the hierarchies of race and gender, but also how citizens are educated in the system. Building *science* literacy is a threat to this control and therefore is left out of science curriculums. Instead, science education is filled with tales of discoveries that led to the industrial revolution, promoting the

economic significance of *Science* over the accomplishments of *science*. Newton's Laws of Motion were a triumph of physics and mathematics but are taught for their applications in simple machines. Faraday's explanations of electricity and magnetism unified two phenomena thought independent from one another, a triumph in curiosity, experimentation, and never ceasing to question. However, this harmonious discovery is taught with emphasis on its applications to the electric motor, generator, and transformers. The products of science education are graduates that seek degrees in engineering fields, not to make discoveries but to make profits. Weaver (2010) posits, "it is valued more within the fields of chemistry, biology, physics…to focus on areas of research that will produce timely and important discoveries that can be transformed immediately into a commercialized product" (p. 45). *Science* has gained the high ground on the planes of the educational battlefields and is highly fortified in its defenses. It instills the belief that the only reason to become a *Scientist* is to discover something that will attract monetary payoffs. Supply and demand are a fundamental staple of economics and *Science* understands too well how to manipulate it. Promoting careers in *science*, on the other hand, would involve educating students on the things that would improve the quality of life for everyone, not just those in a position to afford its benefits.

Postcolonial science also identifies when *Science* imperialistically establishes its principles over the scientific traditions already in place. Harding (1998) argues, "modern sciences…produce patterns of systemic ignorance, and other scientific and technological traditions are more accurate at many of their own projects than are modern sciences at those same projects" (p. 55). Here, Harding claims that modern sciences, although better suited at identifying consistencies within the domain of nature, lack a cultural awareness to determine whether or not identifying those consistencies will provide benefits or detriments. Modern

sciences operate on "the belief that science is well ordered…that any study of its practice is relatively straightforward and that the content of science is beyond sociological study" (Latour & Woolgar, 1986, p. 36). But effects on the population are a necessary component of *science* research. Latour and Woolgar continue, "However…both scientists and observers are routinely confronted by a seething mass of alternative interpretations" (p. 36), making it necessary to have dialogue about how those interpretations can affect all people. In another instance, postcolonial science shows that through European expansion worldwide, all "new worlds" lose their position as an equal domain of culture. Instead, as explorers ventured to new worlds, they returned home with observations that documented people, traditions, agriculture, minerals, rituals, and other observable phenomena. In this sense, every new world becomes a laboratory to the expansionists, where the occupants are studied as objects. Today, *Science* exists in similar practices as it ventures out to cultures that do not match our own and "observes" the people like laboratory specimens. *Science* empowers the observers to label the observed, and therefore is given the authority to treat them like lab rats: keep them fed (barely), keep them in containment, cut them, inject them, and poison them, all in an effort to better understand how to increase demand and profits.

Science, through a postcolonial lens, has taken the enlightenment of *science* and turned it into a cultural nightmare of sorts. In the effort to create a body of knowledge that fantasizes "of a perfectly coherent account for all of nature's regularities, one that perfectly corresponds to nature's order" (Harding, 1998, p. 6), *Science* has marginalized the people who deserve access to the knowledge gained. *Science* has created rules to keep curious minds in line with established doctrines; has self-awarded authority to distinguish between relevant and irrelevant questions;

and has built a world of truth to accommodate those that profit from it the most. According to Harding:

> [Scientific] innovation has moved even more firmly to the base of the contemporary economy. Whoever already owns "nature" and has access to it, whoever has the capital and knowledge to decide just how they can best access nature's resources and how such resources will be used – these are the peoples to whom the benefits of contemporary scientific and technological change largely will accrue. The majority of the world's people…have few of these resources. They do not own parts of nature; they do not have the resources to access its energies and powers; and they are systematically denied access to the knowledge of how to gain access to such parts of nature. (pp. 21-22)

This makes the *Scientific* dialogue, a socio-political one; *Science* is too apparent in the lives of non-scientists to continue to be ignored and left to the *Scientists* to conclude what they believe to be the truths of reality for everyone else. Literacy in *science* strengthens understanding in the corruptive-ness of *Science* by challenging its claims to authority and truths. As long as *Science* is left unchallenged, it not only will add more seemingly irrelevant knowledge to textbooks for the next generation to learn from, but it will also shape the politics that govern the lives of every living creature on this planet.

Politics of *Science*

Understanding *Science* as a tool for political agendas is necessary in understanding its ability to thrive. Unfortunately, good or bad science gets muddled together on the political stage when the constituents would rather be told what to believe rather than investigate for themselves. This makes *scientific* claims political ammunition, where it is altered to fit the platform of a given party. Consider climate change and the debate of global warming: *scientists* study the

effects greenhouse gases have on Earth's climate and have been able to determine that human involvement is responsible for a large increase in greenhouse emissions and has therefore increased the rate of global warming. However, the voters are not told this information directly from the scientists who research the matter; instead we learn of global warming and the effects of climate change through politicians, both current and former. Former Vice President Al Gore has successfully released documentaries on the subject of climate change and the dangers it presents to life on this planet. In fact, the first documentary was *apparently* so good that it warranted a *sequel* – obviously some production company felt the *story* of the first one was too rich to end with just one telling and there were still more visuals that could be used to generate more revenue. In the argument against human-caused climate change, counter points are presented not by experts in the field, but by politicians and talking news-channel heads whose only reference to a source is "according to experts." Therefore, we have two sides of the argument, each one taken by a given political party; voters will choose based on a level (high or low) of science literacy the candidate who presents the side that they agree with. The end result could potentially be life-threatening to a population that did not even have a voice in the election. This is the dilemma with politicizing science for the sake of elections and votes. The consequences are too significant to allow non-experts the microphones to inform the population. But the politicization of *science* extends beyond the televised debate, it is also about how *Science* is used to convince the public that research and funding are necessary for intellectual growth, when in actuality it is for something entirely different.

It is no secret that America's involvement in the Space Race in the middle of the twentieth-century had little to do with actual space exploration. Sure, exploration was the image spread across the mediums, but in reality, the Space Race was about rocket technology and a

desperation for who could get a rocket into orbit first. In 1962 when President Kennedy said "We choose to go to the Moon in this decade and do the other things. Not because they are easy but because they are hard" (Kennedy, 1962), it was inspirational and unified the country (for the most part) into an era of human exploration of space, the last uncharted territory. However, Tyson (2012) provides a different perspective, "By declaring the race to be about reaching the Moon and nothing else, America gave itself permission to ignore the contests lost along the way" (p. 6). This is referring to how the Russians were first to complete nearly every stage of space exploration before America: the Russians launched the first satellite into orbit, the first man into orbit, conducted the first spacewalk, put the first woman into space, and others. America, sparked by fears of Russia's technological superiority and the demonstrated capabilities to put high powered rockets into low-earth orbit, became united in the quest to beat the Russians at *something*; and going to the Moon was it. However, once America landed on the Moon and there was "no chance of [the Russians] putting a person on the lunar surface – we [stopped] going altogether" (Tyson, p. 6). After America ceased missions to the moon, the Russians successfully put a permanent manned space station into orbit. As Tyson posits, "Once again, being reactive rather than proactive to geopolitical forces, America concludes that we need one of those too" (p. 6). When viewed together, the Space Race, colonization, biosciences, medicinal science, and many others, a pattern begins to emerge that shows that politics, war, and profitability continue to trump the urge to discover.

The importance of *Science* in curriculum studies exists here, in its political utilization. Politics, after all, shape every foundation of life, from experiences within cultural differences, to the curriculums *limiting* the education of children. This is why "there is no aspect of science that can be immunized from social and cultural influences" (Harding, 2006, p. 136), because *Science*

can be used to affect life in almost every way. *Science* uses 'objective' methods to make its claims credible, regardless of who is most affected by those claims. For example, *Science* was used (as well as religion) to justify the superiority of white individuals over non-white people, claiming that non-white individuals were lesser forms of human, and therefore permitted to slavery and regarded as property. *Science* determines what vaccines must be mandated for students in the public-school system, and aside from a few exemptions and growing ignorance, most students are immunized resulting in many diseases, once life-threatening, becoming almost eradicated. Each use of *Science*, whether for positive or negative outcomes, are spawned from a political agenda to make change. Harding (1998) writes, "Scientific and technological change are inherently political, since they redistribute costs and benefits of access to nature's resources in new ways" (p. 50). The outlining of who controls what and who can access what is definingly political. This also means that what can be achieved is predetermined by those who control the materials and funding necessary for inquiry.

Research in the sciences is highly politicized because when all the projects are presented, each seeking the opportunities to go further, decisions have to be made since the resources are not abundant enough for all. Historically, the decisions have leaned towards nationalistic ends. Feyerabend (1982) posits, "the superiority of science is the result not of research, or argument, it is the result of political, institutional, and even military pressures" (p. 102). The global stage is rife with nationalized competition, be it militaristic, economical, or educational. Since *Science* is a general pathway towards the future and innovation it is often used to gain ground in these comparisons. In general, *scientists* appreciate the development of new ideas by other *scientists* regardless of ethnicity. Knowledge to them is a global necessity, not currency, and should not be

withheld in order to favor one nation over another. Current *Scientific* research acts differently, however. Feyerabend (2010) argues:

> Increasing amounts of theoretical and engineering information are kept secret for military reasons and are thereby cut off from international exchange. Commercial interests have the same restrictive tendency…There are many ways to silence people apart from forbidding them to speak – and all of them are being used today. The process of knowledge production and knowledge distribution was never the free, 'objective,' and purely intellectual exchange rationalists make it out to be. (pp. 126-127)

The knowledge-currency is a valuable entity, as if 'discovery' is only permittable to those allowed to discover, thus making national defense and economic growth the only permissible research institutions. Only after such discoveries have been utilized to full capacity is the information shared to allow others to continue research for other 'unimportant' ends. Until then, however, the knowledge of discoveries is kept secret until its privatized use is determined: if it can lead to superiority, it is used until it is obsolete; if it does not pose a threat to superiority, it is released to the public. According to Zimmerman (1993), "Today, basic research is closely followed by those in position to reap the benefits of its application – the government and the corporations" (p. 443). Hence the *un*democratic and highly political practice of *Scientific* activity.

Another difference between *scientists* and *Scientists* in terms of cultural influence is that *science* includes a moral compass, deciding whether *knowledge* would lead to destructive or advantageous ends. In regard to this comparison, Harding (1991) argues:

> The insistence on this separation between the work of pure scientific inquiry and the work of technology and applied science has long been recognized as one important

strategy in the attempt of Western elites to avoid taking responsibility for the origins and

consequences of the sciences and their technologies or for the interests, desires, and

values they promote. (p. 2)

Science, then, acts as a tool of ignorance in the utilization of *scientific* discoveries, allowing

Scientists to be morally removed from how governments, institutions, and corporations choose to

use the information. Of course, *Scientists* are not too far removed from their developments to

recognize how it will be used. The scientists of the Manhattan Project knew they were

developing a weapon with a destruction capability unheard of at the time. They knew the weapon

might be used and that when that time came, it would be for the good of America and her

interests. However, after the reports of the destruction that occurred in Hiroshima and Nagasaki

had reached them, most fell into deep remorse (Ham, 2015). Some became members of

committees for atomic energies and nuclear weapons, urging that further development in these

weapons would ultimately lead to a global apocalypse. However, the weapons have still been

developed, even more powerful than the ones used in Japan. *Scientists* continue to work on these

technologies knowing full-well the devasting capabilities they bring. Morris (2004) concludes:

> Dropping bombs is basically an enterprise without a face…Dropping a bomb is
>
> psychologically easier for perpetrators to handle because they don't have to see the
>
> Other; they don't have to really think about the consequences of their actions. If
>
> theoretical physicists were called upon to look into the face of the Other, perhaps they
>
> might think twice about what they were doing in the first place. (p. 47)

Therefore, the politicization of *Science* will always be in the development of new technologies

and new understandings that only have positive effects on the ones removed from the arenas the

technologies are used. The use of nuclear energy for example could be a radical shift in how the

world, especially in poverty-stricken areas, could gain access to clean (greenhouse emission 'clean') abundant energy. However, unless the research in nuclear energy is guided towards its weaponization it will not be given the priorities it needs to be well funded and available for community *scientists* to get involved.

Albert Einstein's popularity in pop culture grew from his theories of relativity, radically reshaping the world's understanding of the universe. These theories developed out of his ability to perform "thought experiments" which to anyone else would simply be a daydream. The importance of daydreams, however, cannot be overlooked for they allow the mind the space it needs to be curious, imaginative, and innovative. Einstein's relativity theories had no practical application at the time to warrant any attention, but they were the result of an imaginative, free-thinking intellect. Today however, such thinking and curiousness is squashed early in human development. *Scientists* are no longer allowed to be curious about the unknown, but rather expected to be curious about how to capitalize further. Morris (2004) writes, "Repressing daydreams produces a sort of sickness, a cultural sickness, that is so much a part of the American landscape" (p. 37). In an environment where time is money, daydreams are wasteful and produce nothing of value and are therefore shunted. The purpose of *Science* is to better national defenses, improve profitability, or promote national stature above other nations. Therefore, curiosity of the unknown is not given a platform to flourish in the lesser-valued *sciences*.

It is not just curiosity in the unknown that is denied, but *scientific* inquiries that seek to better the quality of life for all people is also overlooked. Providing knowledge and information that could potentially improve poverty and healthcare access is empowering and closes the gap between the 'haves' and the 'have-nots' and is therefore a threat. Through patterns of scientific

recognition by higher authorities, both *science* and *Science* have steered away from benefiting everyone regardless of race or socio-economic status. Dyson (2006) writes,

> The failure of science to produce benefits for the poor in recent decades is due to two factors working in combination: the pure scientists have become more detached from the mundane needs of humanity, and the applied scientists have become more attached to immediate profitability. (p. 26)

Because of this, progress is only considered progress if there is monetary benefit associated with it. Even *science* is not immune from political agendas and desires. Harding (2006) argues, "The sciences have not been scientific *enough* to chart the complex relations between their supposedly purely natural objects of study and the economic, political, social, and cultural assumptions and priorities that they and their cultures bring to scientific projects" (p. 63). Consider the 'natural object' of *science* attempting to understand human genetic code. In its discovery, the ability to map the genetic code has opened a Pandora's box of applications that go unchecked in their effects on people. For example, Kitcher (2001) writes, "the explosion of genetic knowledge will have immediate consequences of a much darker kind" (p. 5). By understanding the genetic sequence, bioscientists will be able to offer a plethora of predictive genetic tests, allowing would-be parents an opportunity to know if an unborn child will be susceptible to certain diseases, birth defects, or lifelong physical or mental handicaps. Genetic testing also reveals information that could offer new forms of discrimination. Kitcher continues, "it is highly likely that a significant number of people will confront information that is psychologically devastating…be excluded from a job on genetic grounds, or be denied insurance through genetic discrimination, or face an acute dilemma about continuing a pregnancy" (p. 5). This creates a new cultural division where on one side, the humanity of civilization recognizes diversity as

empowering, whereas the other side, call it logic-ism, questions whether an individual can contribute to the greater good economically, or will the individual be a burden on that economic structure. Like all things in politics, so long as the debate is kept within the population, the elite can remain at their status and only grow in power and control.

The elite's control of research is spread through multiple instruments. Zimmerman (1993) suggest, "The ruling class, through government, big corporations, and tax-exempt foundations, funds most of our research" (p. 442). Therefore, research will always be guided by an agenda, even if that agenda is not specified. Further, *Scientists* that have contributed to the political agenda are then given privilege to pursue research of their own interest. Haraway (1989) argues this when she states that after the post-war era, scientists that emerged from the militaristic research programs used that experience to "[hone] their sense of entitlement to pursue publicly financed 'pure research,' i.e., without much social accountability or democratic process for setting scientific and medical priorities" (p. 120). *Scientists* were given full autonomy in their research so long as they also contributed to elitist needs when called upon, especially since "scientific research is an important part of the economic base of modern Western societies" (Harding, 1991, p. 4). *Science*, then, has become less of a knowledge-building enterprise and is more representative of corporate dealings. "The sciences of today are business enterprises run on business principles" argues Feyerabend (2011) (p. 73). The pursuit of knowledge has been rendered obsolete so long as the powerful continue to build wealth and dominance. Only when this growth begins to slow will *Science* be permitted to discover the next package of 'relevant' knowledge.

The politics that drive research also cause the sciences to become instruments in social structures and hierarchies. Because science is left out of public involvement, its practices and

results are considered objective and universal in their applications. *Scientists* may be unwilling to see the truth of how their work affects people, especially in marginalized positions, but *scientists* are kept in the dark of these effects as well, told by their benefactors how the research will be used. Harding (2006) says,

> sciences and the philosophies that cannot recognize and do not engage with how scientific practices themselves inadvertently legitimate and further disseminate political and cultural values and interests usually end up complicitous with the agendas of dominant social groups. (p. 95)

Because *Science* is believed to be objective, it ignores issues of social hierarchies by reducing everything to data. Data, they argue, is free of values and does not carry indicators of social status, race, sexual orientation, or gender. Therefore, *Scientific* conclusions based on the data are unbiased and must be universal in their application. Ribes and Jackson (2013) argue "data have domesticated science not only in the sanitized environments of the industrial data center, but also at every stage, moment, and site of scientific activity" (p. 152). Therefore, *Science* is able to operate successfully because it reduces everything to data points, and because *Science* is left out of public debate, the people have effectively allowed this to occur. When everything is reduced to quantified data, it removes ethical challenges. When trees are cut down to make room for new buildings, surveys of the land are reduced to square-footage and therefore does not consider the ecological impact this action will have on the environment. When certain areas of a community are deemed unsafe or in need of renovation, the public is informed of the improvements that will be made, but not how families and local businesses will be impacted. Ribes and Jackson continue, "In order to support our growing appetite for scientific knowledge, we have entered into a symbiotic relationship with data – remaking our material, technological, geographical,

organizational, and social worlds into the kind of environments in which data can flourish" (p. 152). Ignoring the social contexts of research and weaponizing *science* to serve social hierarchies are the aspects of *scientific* inquiry that have made the public distrust its abilities to aid humanity. In the next chapter, I will outline how *Science* has effectively contributed to social injustices involving race and gender, and how *Science* has reshaped the environment into its own toy box without reflection of the consequences it has created for the occupants.

CHAPTER 4

CULTURAL *SCIENCE* LITERACY: RACE, GENDER, AND INJUSTICE

"Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less." – Marie Curie

"The whole problem with the world is that fools and fanatics are always so certain of themselves, and wiser people so full of doubts." – Bertrand Russell

"The people up on top, the people who have the power, their power depends on the obedience of people below them. And when people withdraw that obedience…then the makers of war, the profiteers, the purveyors of greed…are helpless." – Howard Zinn

In the 24th century, the crew of the Starship *Enterprise* embark on a journey throughout the galaxy. Their mission: to explore strange new worlds, to seek out new life and new civilizations, to boldly go where no man has gone before. Throughout their journey, the crew engages with scenarios that resemble the societal issues that are present in the non-fiction world. Though the series is categorized as *fiction*, it allows for self-reflecting analysis about the injustices produced by institutionalized racism, sexism, and xenophobia. Barad and Robertson (2001) posit:

From portraying television's first interracial kiss to dramatizing the issues of homelessness, homosexuality, and religious intolerance, the ethics of *Star Trek* has generated a world that strives to be free of the racist, sexist, and xenophobic attitudes that are, unfortunately, still all too common today. By raising these issues, each series challenges us to examine our own values and ask ourselves whether they are defensible, let alone reasonable. (p. xii)

In January 1969, an episode titled "Let That Be Your Last Battlefield" provided a not-so subtle commentary on racial injustices. The crew of the enterprise comes in contact with an alien species whose skin pigmentation is split down the middle: one side white, one side black. The

message series creator Gene Roddenberry hoped to convey was not to comment on white versus black race disparity, but rather to argue that if skin color did not matter (because all individuals are visually half black and half white), differences will still be exploited in order to create arbitrary divisions and injustices. The differences found in these individuals were simply which side of their body was white, and which was black. One arrangement was superior to the other, was justified in enslaving the other, and believed itself morally justified in its actions against the Other. Such *science*-fiction provides opportunities to engage in discussions about how society constructs perspectives of race and gender. Further, speculating what the future might be based on current dynamics is a powerful way to investigate how *Science* has been instrumental in the construction of racial and gender stereotypes and expectations.

When *science* is used to justify racial or gender differences, it becomes *Science* and perpetuates a system of injustice. When economically disadvantaged communities are put center-stage in political debates, the *presumed* consensus is that those communities are themselves at fault, ignoring the socio-political maneuverings that profit from the disparities. *science* literacy is resistance, protest, truth-to-power. It enables individuals to question policy, challenge authority, and shape political platforms. There is a problem when politicians tell voters what they should care about when it should be the other way. But *science* illiteracy breeds followers and corresponding despots to force the narrative regardless of how unfitting it is to our lives. *Science* perpetuates racial stereotypes which leads to fear of the Other or the belief in innate pseudo-superiority. We see the rumblings of this through multiple mediums, from numerous talking heads, which is then absorbed by the masses in search for information that can be fed to them rather than having to investigate themselves. Gender roles in *Science* are also intriguing. While the field of *Science* is predominantly male, the issue is not limited to access to scientific careers.

The presentation of *Science* in cultural institutions provides a significant explanation for the role gender plays within *Scientific* fields and professional recognition for *scientific* inquiries. Identifying these consequences of a *science* illiteracy leads to an understanding of the social injustices that are embedded within the culture; and the first step to solving a problem is being able to recognize that there is one.

The *Science* of Prejudice, Stereotypes, and Oppression

One year I had two racially-different students approach me, separately, about majoring in physics when they go to college. Neither student showed particular aptitude for the subject during their high school physics course with me, so I was definitely a little surprised. For both students I responded with excitement and encouragement, but for one of them I could not help but think they were not being serious. Why? Why is it so unnatural to think two individuals, separated only by the color of their skin are not capable of the same achievements? Somewhere in my own history I learned to think this way, right? My parents never taught me to discriminate against others, I did not grow up in a violent neighborhood, so I did not see one race more violent than the other, even though my town was definitely a cultural melting pot. Why was I hesitant even for just a fraction of a second to be excited and offer encouragement for one student than I was for the other? Another time I had a female student in a physics class who was not a standout in any way, good or bad. She completed average-quality work on time, rarely asked questions, and scored on average in the middle of her classmates on assessments. One day during a whole class conversation about college, I asked her what she planned to major in. She said, "Physics and Nuclear Engineering". For a split second, again, I was hesitant to believe her. Why? What is it about race and gender that makes us hold on to stereotypes no matter how much we consciously want to dismiss them?

Understanding race and gender should not be approached biologically. We have moved far beyond limiting race and gender to biological truths and have instead systematically assigned race and gender to social constructs, expectations, and stereotypes. Haraway (1989) suggests, "Race and gender are not prior universal social categories – much less natural or biological givens. Race and gender are the world-changing products of specific, but very large and durable, histories" (p. 8). Fittingly then, the intersection of race and gender with *Science* is cyclic in that the histories of race and gender generate *Scientific* knowledge, which in turn continues to justify the divisions within race and gender. As Haraway intends to demonstrate throughout *Primate Visions*, history shows that scientific inquiry throughout much of the world was (and by-and-large continues to be) conducted by middle-age white men, which therefore limits natural interpretation to be subjected to the experiences and expectations of such men. This leaves people of color and women out of the conversation and thereby creates a *Science* that is centered on white-male beliefs and expectations. Harding (2006) counters:

> We can see that different social groups, with their different historical experiences and inquiry practices, are indeed capable of making unique contributions to human understanding and knowledge. This seems a far preferable understanding of science than the grandiose and delusional claim that some one group's understanding of nature and social relations is uniquely entitled to represent all of human knowledge. (p. 142)

This is not to say that people of color and women have been completely discarded from scientific inquiry (though they do represent a smaller population of researchers in the field) but that in order for their work to be taken seriously, it must adhere to the white-male foundations that were laid before. Further, if *Science* is a mechanism to make truths about the world and the societies

within, then the world is subjected to white-man truth and by default has systematically created a hierarchy of authority and injustice.

A *scientifically* illiterate approach to race and gender perpetuates the oppressions that are institutionalized throughout the world. Collins (2000) defines oppression as "any unjust situation where, systematically and over a long period of time, one group denies another group access to the resources of society" (p. 4). In terms of *scientific* oppression, *Science* has lived up to this definition by limiting access to scientific dialogues and conclusions. Again, the problem is not limited to only lack of access, but also in not recognizing the autonomy of people of color or women researchers in their work. The image of the professional researcher is dominantly masculine and either white-washes non-white individuals entering the profession or de-feminizes women. Images such as these are prevalent in classrooms and causes non-white individuals and young women to think scientific professions are not for them. Here, then, is the answer to my question, "Why?". Involuntarily, I hesitated for the non-white student and the female student because I immediately defaulted to the image of a physicist or nuclear engineer as a white-male. This hesitation could have given the students the sense that I did not believe them capable of such aspirations, which of course was not the case. But it was not just my pause that could potentially divert these students from professional scientific careers. The idea of a person of color or woman *scientist* is a fragile one: without caution the other forces of conformity and expectation are eager to push these students off the path. Harding (1993b) writes,

> In racially stratified societies such as the United States, most African Americans, Native Americans, and other peoples of color [and women] have not had access to the scarce resources – educational, economic, social – that would enable them even to imagine having a career in the sciences. (p. 198)

Of those "scarce resources", education is of particular interest; specifically, education in the United States resides in the public domain, where equality of access is believed to be the standard. Any educational researcher however, would argue with substantial supporting evidence that this is not the case. As an educator who has worked in two neighboring school systems, I can attest to the falsehood of this claim of equality. In one district, which was almost entirely Title I and housed numerous schools that were on the Governor's watch list for low achievement, course offerings differed widely among advanced courses when compared to the county next door, where almost all schools offer nearly every advanced placement course in mathematics and science. The access to opportunity for students is severely limited by socio-economic hierarchies. "The failure of the sciences to provide an adequate level of *general* science education to racial and ethnic minorities, women, and the working class" is of grave concern in American society (Harding, 1993, p. 3). However, white-male students are within the same walls, exposed to the same curriculums. So how is it that they still have access to career opportunities in the sciences when Harding claims that people of color and women do not? The answer: cultural perception of who professional scientists tend to be. Therefore, the solution is not to dump more non-white individuals and women into science education classes, but to educate students away from this cultural perception by providing a *science* literacy education that disrupts the *Scientifically*-established norm.

How *Science* Constructed Race

To understand the construction of race as it is used in modern society, the inquiry and questioning must venture beyond the *scientifically* established differences of genetics and their respective phenotypes. New forms and definitions of racism arise out of cultural circumstance or perceived superiority and access to things (material or otherwise). Marshall (1993) posits, "The

assignment of individuals to the various racial categories recognized in different societies is often based on perceived behavioral differences rather than on demonstrable physical differences" (p. 120). *Acting* white or black is enough to view someone as part of a *race* regardless of skin color. Growing more popular in political debates is the indistinguishable-from-racist treatment of poor people, non-Christian religious followers, "un-American" individuals, and those that kneel. Skin color, though it still plays a significant role, is not the limiting factor in the discussion. These traits all carry (at least) one similar trait: they are all (white) man-made. "Many scholars in the biological sciences", Marshall argues, "agree that all typological divisions of mankind into discrete racial groups are to some extent arbitrary and artificial" (p. 116). Society, however, builds its policies on these racial groups, punishing those that were not given a choice when they were born into circumstance. Racial construction is therefore a *Science*; an exploitation of social *scientific* data. Haraway (1989) makes a similar assertion: "Wage labor, sexual and reproductive appropriation, and racial hegemony are structured aspects of the human social world. There is no doubt that they affect knowledge systematically" (p. 7). Approaching the issue with *science* literacy, however, keeps the hegemonic structure in view when discussing social constructions. It asks us to think deeply about why divisions in race and gender exist and who benefits from those distinctions.

The *Scientist*, as demonstrated in Chapter 3, is subjected to many influences that guide the direction of their work. No *Scientist* is completely objective. Even if the results are non-discriminatory, it was the project where one finds breadcrumbs of discrimination. Harding (2006) posits:

> It turns out that the work of many biologists and biomedical scientists has made
> important contributions to advancing their culture's racist projects even when the

scientists themselves have not intended such consequences of their work, and sometimes even when they have explicitly intended to recruit science for antiracist projects. Nor is it only these biological and biomedical sciences that have participated in white supremacist projects…Moreover, the agendas of other [scientific] fields…often have prioritized scientific issues of little interest to racial minorities and largely benefiting already advantaged whites, siphoning off public funds for such projects as the U. S. Space program, which are intended to demonstrate the legitimacy and desirability of global dominance by white supremacist Western societies. (pp. 17-18)

As a nation, we rally behind scientifically political initiatives, such as NASA and the Armed Forces because they represent more than discovery and defense; they represent the assertion of superiority for other nations to quiver in front of. Politicians are good at making racist projects seem patriotic. For example, if the President of the United States were to proclaim a new initiative to get (USA-)mankind to Mars, it would be met with resounding patriotism from a large portion of the country. Getting to Mars first tells the rest of the world that America has the best rocket technology, which tells foreign leaders to take heed that America has the best rocket weaponry. Such dominance is what Harding refers to by "white supremacist Western societies". Harding is not limiting the description to neo-Nazis or Klu Klux Klan members, Harding is speaking about societies where the dominant way of life was built from a predominantly white-male perspective. Harding elaborates on this:

A white supremacist society need not be one in which all or any white individuals intend or prefer their supremacy. It can also reasonably designate societies where most whites report that they oppose white supremacy, yet the values and social structures of the society de facto maintain racial inequality. (p. 18)

Therefore, the work of *Scientists* in these societies can effectively push the agenda of white supremacy ideals, even if the outlined intentions specifically argue against such views. Further, this is how *Science* has aided in the institutionalization of racism.

Since the concept of race is so embedded in cultural life, it is easy for *scientifically* illiterate individuals to not pose questions about man-made understandings, especially when the cultural norm has been standardized by white Eurocentric viewpoints. You do not need to be *scientifically* literate to see racial injustices, but without *science* literacy it is very unlikely to identify how actions perpetuate the racist narrative. Harding (1991) argues, "We replicate the oppression characteristic of androcentric discourses if we fail to observe that scientific and technological benefits accumulate for…whites, and the economically over-advantaged as the correlative disadvantages accumulate for Third World peoples, 'minorities', and the poor" (p. 36). Technological benefits, for instance, could effectively create a new 'race' of individuals: those who can afford technological enhancements – perhaps for health or vanity reasons, and those who cannot. Without the necessary dialogue in science classrooms to engage learners in revealing how *Science* builds separation within the population, these students will grow and develop into career fields that will not challenge the system but advance it. According to Harding (1993b):

> It cannot be emphasized enough that it is not primarily those who have been denied access to the sciences who need to be changed in order to achieve racial balance in the sciences. The causes of that exclusion are to be found in the institutional racism of U. S. society and its sciences and in the narrow and ignorance-producing nature of what are regarded as the very best science educations. It is not only those excluded from the best science educations who exhibit "scientific illiteracy." (p. 200)

Therefore, understanding *Science*, whether pure (biology, chemistry, etc.) or social does not equate to having a color-blind perspective on the world. The research produced, questions asked, and funding sources are all in some way guided by certain institutionalized philosophies whether the *Scientist* is aware of them or not, and a critical literacy in *science* is a necessary additive to science curriculums in order to address this issue head-on.

The *Science* of Being Colorblind

In introductory biology classes students learn about the basics of genetics and how certain traits are passed from parents to offspring. Certain traits are recessive, and certain traits are dominant (i.e., if a dominant trait pairs with a recessive trait, the dominant one wins). Students also learn that certain diseases, handicaps, and abnormalities are caused by certain sex-linked traits (meaning they are tied to the X- or Y- chromosomes). Biological males, for example, carry XY-chromosome pairs while biological females carry XX-chromosome pairs. Colorblindness is a recessive trait that is carried by the X-chromosome, which means unless both chromosomes carry the trait, a female cannot be colorblind. A male however is more likely to be colorblind since they only carry one X-chromosome. This is the biological understanding of colorblindness, a *scientific* understanding. The *Science* of colorblindness is an entirely different entity; one of social construction filled with stereotypes and institutionalized prejudice. A declaration such as "The Law" is an example of *Scientific* colorblindness, because although "The Law" applies to everyone it is utilized differently depending on community, skin color, or socio-economic status. Possessing *science* literacy helps to identify how *Science* continues to marginalize groups of people while building a system that claims to be fair, just, and colorblind.

Thinking critically about race is not about recognizing that people of color are subjected to unfair situations, but about understanding the systems and institutions that allow for their

(mis)treatment. Feeling an emotional response to racial atrocities in the news is not a testament to colorblindness or being nonracist, because at the end of the day the news can be turned off and life goes on. Alexander (2012) argues, "The current system of control depends on black exceptionalism; it is not disproved or undermined by it…racial caste systems do not require racial hostility or over bigotry to thrive. They need only racial indifference" (Introduction, para. 36). Understanding this system reveals the nature of power, which is only capable of exertion if those subject to its rule allow it (see Howard Zinn quote at beginning of chapter). Collins (2000) adds, "Suppressing the knowledge produced by any oppressed group makes it easier for dominant groups to rule because the seeming absence of dissent suggests that subordinate groups willingly collaborate in their own victimization" (p. 3). Therefore, the development of laws, law-enforcement policies, community structures, media coverage, are all meticulously crafted to uphold a narrative that maintains an obedience. One could say there is a certain *Science* to this process. *Science* is a mechanism that helps create a system where obedience is abundant, and resistance is scarce. Critical debate is absent because most policy formation happens in closed-door meetings, news directors are manipulated by political party affiliation, and the people are left to believe (and accept) the obligatory fallout of their class.

The cultural perception of being colorblind is arguably understood as providing people of color opportunities that were not available to them decades prior. If people of color have more access to education, jobs, and other forms of life's enjoyments, then as a whole society is becoming more colorblind. However, being colorblind is not enough because it does not change the underlying assumptions that constantly reinforce the institutionalized (mis)treatment of the Other. Collins (2000) uses experiences of Black individuals in the working class to highlight the treatment of workers, despite being given the opportunity to work in the first place. Collins

writes, "Historically, working-class Blacks have struggled with forms of institutionalized racism directly organized by White institutions and by forms mediated by some segments of the Black middle-class" (p. 28). As a specific example, Collins outlines the experience of a Black female manager who was tasked to travel to another state to conduct a presentation of her own work. However, her boss felt it necessary to make her recite her work repeatedly in front of him as if she was incapable of doing a good job. To further add to the racism, the boss then proceeded to instruct her how to navigate through an airport, as if to believe it was impossible that she had ever had the opportunity to fly commercially before. Because this employee was given a position of relatively high status, we are persuaded to believe that racism is dead and that all members of society can rise to the same levels of distinction and authority; however, it is ignored how people of color are often mistreated in those roles when compared to the dominant class.

The mistreatment of people of color has been the foundation of all racial disparities throughout history. To argue against racism, small "benefits" have been the go-to to proclaim nonracist intentions, such as food, shelter, and clothing for slaves during the colonial period. But the institutions of racism are strong and thriving because they reside not on the surface of racial treatment, but in the details. Alexander (2012) remarks, "Since the nation's founding, African Americans repeatedly have been controlled through institutions such as slavery and Jim Crow, which appear to die, but then are reborn in new form, tailored to the needs and constraints of the time" (Chapter 1, para. 5). In this specific instance, Alexander is setting the stage for a discourse about how the U. S. Government's "War on Drugs" initiative is just Jim Crow Laws reincarnated. The argument is while the War on Drugs was publicly declared to clear the streets of America of illegal substances, the evidence shows that the punishment for such crimes is severely disproportionate between white and non-white perpetrators. A white teenager,

Alexander argues, caught with cocaine could face jailtime that can be counted in weeks or months; but a black teenager caught with marijuana (a severely less potent drug compared to cocaine) is more likely to be punished with jailtime that can be counted in years or lifetimes. Effectively then, the War on Drugs is a systematically developed policy that allows for the mass incarceration of people of color. The *Science* behind the development of the policy is influenced by skewed statistics, a prison-for-profit system, and the targeting of individuals with whom society already equates to a lesser status. In other words, *Science* in the case of the "War on Drugs" is utilized to generate data and draw conclusions about the effects of illegal substances being bought and sold on American streets suggesting drugs are a nationwide problem, yet it ignores how the policy targets non-white individuals by justifying harsher punishments and life-long consequences when compared to perpetrators that are white. Had the "War on Drugs" been created using *science*, perhaps solutions could have been enacted to solve the root problem of drugs in America and not quickly move towards mass incarceration of people of color, effectively creating a system that furthers institutional racism and control over people of color and their communities. Alexander writes, "Sociologists have frequency observed that governments use punishment primarily as a tool for social control, and thus the extent or severity of punishment is often unrelated to actual crime patterns" (Introduction, para. 18). For people of color, the punishment extends beyond prison time since once released, these individuals carry the label of criminal for the rest of their lives resulting in loss of access to jobs, education, and social benefits. Overall, the circumstances remain intact since most white individuals can rest easy knowing they are less likely to fit the description of criminal. Hence, the system thrives.

The War on Drugs, like many other policies, are built upon a desire to maintain control. The *Science* behind such initiatives is what helps them develop within the institutions that are

foundational to our society, like racism. However, *Science* claims to exists in a fantasy where its inquiries are objective and free of bias. So, is *Science* colorblind? Alexander (2012) writes:

> Seeing race is not the problem. Refusing to care for the people we see is the problem. The fact that the meaning of race may evolve over time or lose much of its significance is hardly a reason to be struck blind. We should hope not for a colorblind society but instead for a world in which we can see each other fully, learn from each other, and do what we can to respond to each other with love. (Chapter 6, "Against Colorblindness," para. 11)

Therefore, though the ability (or consciousness) to not see color may be identified as colorblind, it does not mean anything towards the treatment or understanding of the marginalization of people of color in society. Hence, to ask if *Science* is colorblind is irrelevant since whether it is or not, it still does not fight against the institutional racism that exists in culture. Instead, *Science* helps to propagate the status quo into different systems so that control and power can be maintained in the evolving world. If it is accepted that the concept of race is constructed and can therefore change, we must think critically about what the next iteration of race-driven policies means for society and who will be its next targeted population.

Gender-*Science*, Feminist-*science*

There are many ways to understand the position of women in the *Sciences*. What it means for women to think *scientifically*, how male-dominated *Science* affects the lives of women, or the simple observation of too few women *scientists*, each dynamic contributes to the larger narrative that *Science* is a tool that not only builds racial structures, but gender ones as well. Women have been on the losing end through much of American history, and like the racial discussion above, providing women with opportunities that have traditionally been exclusive to white men is not

the answer. The treatment and expectation of women is just as institutionalized as racism in this country. Women are expected to engage in certain activities that fit a stereotype, as are men; however, the expectation of men is always one of power, authority, and dominance whereas women are expected to be obedient, dependent, and nurturing. Critical-*science* literacy can help identify these cultural institutions in order disrupt the norm.

The reason for the low population of women *scientists* can be traced to many things, but in terms of education it is curious why more women do not choose to go into scientific careers. Female students are experiencing the same instruction as male students, so access is not as much an issue as it once was. One perspective is that *scientific* thinking is accepted as a masculine process: logical, objective, unemotional. For many adolescent women still establishing an identity, thinking "like a man" is off-putting and could be considered a main reason scientific fields have fewer women *scientists*. Keller (1995) elaborates:

When we dub the objective sciences "hard" as opposed to the softer (that is, more subjective) branches of knowledge, we implicitly invoke a sexual metaphor, in which "hard" is of course masculine and "soft" feminine. Quite generally, facts are "hard," feelings "soft." Feminization has become synonymous with sentimentalization. A woman thinking scientifically or objectively is thinking "like a man"; conversely, a man pursuing a nonrational, nonscientific argument is arguing "like a woman." (p. 77)

The solution to this would be to address the cultural stereotype that women are irrational or can only think subjectively. This is a dangerous belief as it causes a natural de-accreditation of women, their values, their struggles, and their voices. However, like race, gender has become more of a socially constructed idea than a biological one. Perhaps it has always been socially constructed and society has just been too narrow-sighted to fully comprehend gender.

Understanding gender as a social construction is an important perspective for *science* literacy. After all, *science* literacy is an empowering way of thinking that recognizes all social dynamics as socially constructed in order to submit to hegemonic systems. It is as if *science* literacy is the child who continues to ask "why" no matter how many answers they are given. Eventually, asking "why" enough times about social constructions leads to the deep-rooted stereotypes that shape perception and expectation of any particular group. It is *Science* that creates those perceptions by using blanket observations, poor methodologies, and politically-motivated intentions. Keller (1995) argues, "Science is the name we give to a set of practices and a body of knowledge delineated by a community, not simply defined by the exigencies of logical proof and experimental verification" (p. 4). The understanding of *Science* and its purpose is therefore just as much a social construction as the subjects it claims to understand. Therefore, Keller continues, "Women, men, and science are created, together, out of a complex dynamic of interwoven cognitive, emotional, and social forces" (p. 4). This is what helps assign *Scientific* thinking as masculine, because they are created together from the same perspective. Women, then, are *Scientifically* constructed to be feminine, but only for desired purposes of control and exclusion. Keller adds:

> The most immediate issue for a feminist perspective on the natural sciences is the deeply rooted popular mythology that casts objectivity, reason, and mind as male, and subjectivity, feeling, and nature as female. In this division of emotional and intellectual labor, women have been the guarantors and protectors of the personal, the emotional, the particular, whereas science – the province par excellence of the impersonal, the rational, and the general – has been the preserve of men. (pp. 6-7)

Science, then, belongs to men and is therefore influenced by the hegemony of male-dominated institutions. Arguing against this is *scientific* and necessary. Exclusion in scientific careers (or any profession), then, is wholly the result of the *Scientific* construction of what roles are meant for men and which are meant for women.

The control of the lives of women is also a purely *Scientific* manifestation. Who decides what is best for women is not a discourse that typically heeds the voices of women. Roberts (1993) writes, "Unfortunately, science is a storytelling practice conducted primarily by men" (p. 4) and therefore is used to subject women to the whims of male-dominated societies. Haraway (1991) argues:

> Women know very well that knowledge from the natural sciences has been used in the interests of our domination and not our liberation, birth control propagandists notwithstanding. Moreover, general exclusion from science has only made our exploitation more acute. We have learned that both the exclusion and the exploitation are fruits of our position in the social division of labour and not of natural incapacities. (p. 8)

Yet, *Science* continues its attempts, quite successfully, to reduce women to objects of manipulation, as tools in political agendas, and argue against femininity should women defy these expectations. As an example, Harding (1998) writes, "When [experts] assume that 'science' refers only to what physicists and chemists are willing to think of as model sciences…then many science and technology issues central to the lives of women…will not even be seen as relevant issues" (p. 85). Further, women are reduced to an equivalency of subjects to be observed, generalized, and placed within a paradigm that agrees with the *Science* that studies them. Women are not "subjects" to be studied, but women also find it difficult to acquire positions of power that would allow a shift in the paradigm, a *scientific* revolution.

The Defense of *Science*

Given all that has been discussed, how has *Science* continued to grow its influence in shaping the landscape as it is experienced? The answer lies in a return to the root definition of *Science* versus *science* distinction. *Science* operates with the perception of being objective and therefore anti-racist and non-misogynistic. Further, this image is given credibility because most lack a *science* literacy to question otherwise. Stepan and Gilman (1993) argue, "By thinking of science as objective, scientists have been in a position to dismiss areas of knowledge from the past that are now viewed as obviously out of date and biased – such as scientific racism – as nothing but 'pseudoscience'" (p. 172). Therefore, by considering the racist and sexist products of *Science* to be a "pseudoscience", *Scientists* are able to avoid responsibility, consequences, and can argue that such allegations are misguided. It is up to *scientists* to confront these systems and challenge their authority. Dyson (2006) writes, "The ethical standards of [*Scientists*] must change as the scope of the good and evil caused by [*Science*] has changed. In the long run…ethical progress is the only cure for the damage done by [*Scientific*] progress" (p. 26). A critical *science* literacy may be the only way of thinking to ask "Why" enough times to eventually get the *Scientific* community to own up to its improper utilization.

The racism and sexism of *Science* is only seen through a critical analysis of the development and utilization of *Science* in society. Possessing a *science* literacy is progress because questioning power structures is usually enough to initiate discussion and debate. First, recognizing the manipulation of *Science* to garner control is vital. According to Roberts (1993), "Through its blind sexism, science imposes a false universality…science's grand narrative has been used to justify the oppression of subordinate groups, including women" (p. 4). By questioning *Science*'s influence, the oppressive narrative can finally be given some much needed

attention. Next, addressing the supposed "conclusions" of *Scientific* theories that are directed towards the lives of women must be challenged. Harding (1991) posits, "Scientific theories have been used to move control of women's lives to those who exercise power in the dominant class, race, and culture" (p. 35). For people of color and women, white-men are the epitome of the pseudo-expert, yet their control determines what is "best" for the lives they know nothing about. Feyerabend (1982) contributes to this argument by writing, "It is conceited to assume that one has solutions for people whose lives one does not share and whose problems one does not know" (p. 121). Finally, white-male Eurocentric thinking is a world-phenomenon that affects lives on a global scale. Feminine-*science* argues against such imperialistic *Science* and is therefore an important dialogue for all parties to engage in. Harding asserts, "all of the world's people's bear the consequences of policies made in the West, but they do not get a fair share in making decisions that will have such powerful effects on their lives" (p. 4). Roberts adds, "Because science wields power as a source of legitimacy for ideology, women [and people of color] need to pay attention to the discourse of science" (p. 4). Challenging the narrative, resisting the control, and arguing against the tools of *Science* is *science* literacy, and it fights the inherent structures that plague the world-culture.

CHAPTER 5

TECHNOLOGY AND THE ENVIRONMENT: VOLUNTARY IGNORANCE AND *SCIENCE*

ILLITERACY

> "We used to look in the sky and wonder at our place in the stars. Now we just look down and worry about our place in the dirt." – Matthew McConaughey as Cooper, *Interstellar*

> "The situation of mankind today is like that of a little child who has a sharp knife and plays with it" – Albert Einstein

> "If all the insects were to disappear from the earth, within 50 years all life on earth would end. If all human beings disappeared from the earth, within 50 years all forms of life would flourish." – Jonas Salk

> "Shall I refuse my dinner because I do not fully understand the process of digestion?" – Oliver Heaviside

Early on, I knew I wanted to write about *science* literacy and how the lack there-of created a dependency on technology, the destruction of the environment, and how these two things were not necessarily mutually exclusive. Around the same time, I found out that one of my favorite movie directors, Christopher Nolan, was making a new (non-*Batman*) movie to include his trademark complex story-telling about worm-holes and interstellar travel. Because I knew (a little) about worm-holes and Einstein's theories of relativity and time dilation, I knew this movie would be riddled with advanced physics topics. Needless to say, I was excited. Nothing revealed too much about the plot leading up to the movie's release: astronauts were going to travel through a worm-hole, taking them to another galaxy and they would visit other worlds. However, when I saw the movie, not only was I blown away by the film itself, but the full plot hit very close to home: The Earth is dying – crops are disappearing, the atmosphere is becoming more unbreathable, and humanity needs to find a new home before its extinction. This was my reason for wanting to write about *science* literacy, to argue in favor of action against climate change and the wastefulness of consumption. I also saw something poetic and telling

about who we have become as humans: we use to be a species that used *science* to further our

understanding, but now we use *Science* to further profits at the expense of sustainable practices

(see McConaughey's quote at beginning of chapter). Therefore, this is why I write about *science*

literacy; and more specifically, this is why I choose to write about technology, the environment,

and *science* literacy now.

Manufacturing Uncertainty and Voluntary Ignorance

Arguably, most political maneuvering is dependent on two things: manufacturing

uncertainty and voluntary ignorance. The former describes the art of constructing doubt where

none should exist, such as arguing against vaccinations or arguing in favor of a flat earth. The

latter is the conscious choice of looking the other way, as it were, on issues that are blatantly

obvious, such as institutional racism or making an act of silent protest against racial injustice

about disrespect for the armed services. Different cultures around the world are persuaded by

manufactured uncertainty from state-sponsored media outlets, politicians, and conspiracy

theorists. Much like the *Scientist* and the pseudo-expert (Chapter 3), these manufacturers seek to

control narratives in favor of some agenda, typically one that favors profits over people, or more

importantly, power *over the* people. In the conversation about *science* literacy, these

propagandists become *Scientists*, attempting to provide misinformation in order to sell a specific

perspective. These *Scientists* are then commissioned to help shape public perception for

companies, politicians, and the apparent meaning behind actions. Michaels (2008) writes,

"Manufacturing uncertainty on behalf of big business has become big business in itself. 'Product

defense' firms have become experienced, adept, and successful consultants in epidemiology,

biostatistics, and toxicology" (p. 93). Here, Michaels draws attention to companies that have

verifiable effects on the health of its consumers, like the tobacco industry. Such corporations rely

heavily on the ability of these *Scientists* to convince the general public to distrust science. Michaels adds, "In fact, many of these manufacturers of uncertainty do not want 'sound science'; they want something that sounds like science, but lets them do exactly what they want" (p. 103). Unfortunately, this process helps build more institutionalized *science* illiteracy as people become more likely to believe in the faultiness of *science* and the credibility of conspiracy.

Understanding the human body should be an essential part to any curriculum. Not just the biology of the body, but the processes, the systems; the anatomy and physiology should be an essential part of every student's education. Those of us who did not have such an education become dependent on medical experts to tell us what is going on. As a *science*-minded individual, I can accept my doctor's diagnosis because I know he ran lab tests on my blood, urine, or cheek cells; but my experience is fortunate since I see a doctor that happens to trust the *science* before he trusts his own opinionated conclusions. As for those who do believe their doctor's opinion to be infallible, these are the individuals who are likely to believe that the *science* behind the claim that smoking causes lung cancer is faulty at best. The data is incomplete, bias, or contaminated, as the spokesmen for the tobacco industry wants everyone to believe. Oreskes and Conway (2008) discuss the R. J. Reynolds Tobacco Company, which hired *Scientists* to develop a "Medical Research Program", whose purpose was to "support research that might help them avoid legal liability, either by establishing causes of cancer other than smoking or by complicating causal links between lifestyle and cancer" (pp. 66-67). In this instance, *Scientists* found it easier to convince the public in their favor by not arguing the claim that smoking causes cancer, but by arguing against the *science* that linked smoking with cancer. Michaels (2008) suggests, "debating the science is much easier and more effective than debating policy" (p. 92), and therefore becomes the weapon of choice when manufacturing uncertainty.

The attack on *science* literacy is coming from two fronts: from those that wish to cast doubt on science itself, and the individuals who choose ignorance over knowledge. Each are formidable foes; ignorance, however is a different beast because it is not strictly the result of access to information but to some degree a choice or unwillingness to develop understanding or engage in the discussion. Proctor and Schiebinger (2008) posit, "Ignorance can be made or unmade, and science can be complicit in either process" (p. 3). In my definition of science, making ignorance constitutes *Science* while unmaking ignorance is *science*. However, ignorance is more desirable for a system dependent on complacency and therefore, building *science* literacy becomes a real challenge. So long as people choose to ignore factual information, they can be exploited and manipulated, power structures can remain firmly in place, profiteers can continue to ascend to monetary heaven. Returning to the example of healthcare, many people choose to remain ignorant about their own health, as if not knowing about a particular ailment protects one's self from its diagnosis. Similarly, the majority of patients listen to television ads for certain medications promising a multitude of benefits from lowering cholesterol to longer-lasting erections and believe these benefits outweigh potential side effects. The issue is further propagated by licensed professionals who accept persuasion from pharmaceutical representatives and push their drugs without proper diagnoses. Michaels (2008) writes, "It appears that the pharmaceutical industry is devoting sizable resources to the conduct of studies whose results will increase sales, but will not necessarily provide the information physicians need to select the best drug for their patients" (pp. 98-99). Further, patients are then led to believe that drugs are the answer and, in some cases, believe a drug is working even though physical evidence does not support that. In other words, patients are more likely to agree to higher dosages of ineffective medications before researching whether the drugs are effective in the first place. The only

guaranteed benefits go to the pharmaceutical companies as they know their drugs may not cure certain ailments, but they will cause the body to form dependencies on the drug, thereby creating a steady revenue stream at the expense of people's health.

Constructing ignorance empowers its manufacturers to effectively discredit those that challenge the integrity of their employer's products. Tobacco companies have effectively convinced people to continue to buy cigarettes, even with a Surgeon General's warning printed on the package linking smoking to cancer. Pharmaceutical companies have convinced patients to buy drugs, even when their advertisements warn of side effects that are worse than the ailment itself (like certain forms of cancers, heart attack, stroke, or death). But, ignorance is not to blame entirely. After all, I am ignorant about many things, but that does not excuse me from appreciating the importance of those things. This is the thinking behind the Heaviside quote at the beginning of this chapter: as a self-educated mathematician, Oliver Heaviside attempted many times to have his work published by the Royal Society, but his proposals were too un-conformed to the mathematics of the time and was routinely rejected, even though his work was easily provable and applicable. In response to one such rejection, Heaviside wrote back to the members of the Royal Society criticizing their narrowmindedness, which involved the quote provided. In essence, just because one may not understand the full details of any given thing, it does not excuse one from having direct experiences with that thing. Therefore, being ignorant because of lack of exposure to information is not as much the problem as being ignorant and choosing to remain that way despite the available evidence: a voluntary ignorance.

If there is a voluntary ignorance, there must also be an accidental ignorance. In this case, accidental ignorance is when there is a lack of knowledge simply because one has not been exposed to or had the opportunities to learn about any particular thing. Further, if one's exposure

is limited to questionable techniques of information-gathering, then ignorance is not their fault. As an example, Michaels (2008) posits, "scientists, along with the corporate executives and attorneys who hire them, convince themselves that the products they are defending are safe, and that the evidence of harm is inaccurate, or misleading, or trivial" (p. 101). This does not make the situation forgivable, but it does suggest an explanation for how spokesmen are able to convince the population to go against *science*, or at least cast doubt on *scientific* methods and conclusions. Michaels continues, "It is possible that their allegiances were so tightly linked with the products they'd worked on, as well as the financial health of their employers, that their judgments became fatally impaired" (p. 102). This means *science* illiteracy is not limited to those without scientific training, but also to those in research roles whose projects have direct effects on the lives of others.

When *Scientists* are tasked with manufacturing uncertainty, casting doubt on *science*, or constructing ignorance, their research is then part of an institution that chooses profits over people. Oreskes and Conway (2008) posit, "The impact of these research programs is hard to assess, but their purpose is not" (p. 68). *Scientific* research is profiteering and exploitation, attempting to tip the scales in favor of corporations before truly benefiting the consumers. Developing cultural *science* literacy attempts to render *Scientific* research obsolete since the population would be too aware to be fooled into doubting *science*, be made ignorant, or continue to be ignorant. In order to effectively engage in policy formation, all members of society must be willing and able to critique and challenge claims; equipped with the knowledge and tools to understand which information is reputable and which is hearsay. The manufacturers and ignorant-constructionists are not equipped with the *science* to create arguments. According to Oreskes and Conway, "When scientific knowledge challenged [corporate] worldview, these

[*Scientists* respond] by challenging that knowledge" (p. 80). We must become *scientifically* literate enough to not allow *scientific* knowledge to be challenged, and instead use that literacy to challenge the claims of the pseudo-experts and identify the agendas behind *Scientific* research.

Technoscience and Nonconscious Cognition

To begin a discussion of technology through a *science* literacy perspective requires a particular view of what technology is and is capable of. First, I want to define the intersection of *Science* and technology, technoscience. According to Stiegler (2007), the development of technology is the result of a "permanent innovation" to support industrial needs. Stiegler posits, "It is thus the cooperation of technology and science for the benefit of industry which makes sensible to the bodies and the hearts the inherent dynamic of technology" (p. 30). Therefore, it has become *Science* to develop new technologies and incorporate them within culture, regardless of its effects. Further, Stiegler suggests that technology, "which is commonly conceived as applied science by means of technical methods, authorizes a *reversed point of view* and which we describe here as an *overturning*, where *it is science which becomes applied technology, and not technology applied science*" (p. 31, emphasis included). This is an important distinction since it shifts the paradigm of control from *science* to the *Science* of technology. In other words, it is technology that determines the development of *science*. Stiegler continues:

> Science as applied technology produces formalized results which become duplicable, i.e. *reproducible, in general by automatisms*, thus implementing *a specific universe of automatic reproducibility*, while it is no longer obvious that contemporary science, like technoscience, is satisfied to *follow* causal series: it uses them. (p. 31, emphasis included)

Technology then can be understood as a *Science* in-and-of itself, a technoscience, manipulating the processes of *science* to further its development for industrial and capital gains.

Identifying the technoscientific landscape with a *science* literacy lens shows the interplay between *science* and technology, moreover, how technoscience seeks to use *Science* to develop a reality in which it can flourish. This causes a shift in the paradigm of how industry interacts with *science*. Stiegler (2007) argues, "Science is then no longer that *in which* industry invests, but what is *financed by* industry to open new possibilities of investments and profits" (p. 32, emphasis included). This becoming technoscience, shifting from an inquiry to a profit-driven-innovator is dangerous because it creates a pseudo-reality where consumption is believed necessary and an obligation for all to participate in. Stiegler continues, "This science become technoscience is less what *describes* reality than what it *destabilizes* radically. Technical science no longer says what *is the case*: it *creates* a new reality" (p. 32, emphasis included). Seeing technology as the controller of *science* and therefore as capable of creation in both the technical and industrial, suggests that technology is purposeful in the way that humans are purposeful. Therefore, technology must be understood not as the creation of *science* or *Science*, but as a cognitive entity capable of more than we may want it to be.

To understand the cognitive capacities of technology, Hayles (2017) suggests, "Technologies develop within complex ecologies, and their trajectories follow paths that optimize their advantages within their ecological niches" (p. 33). Further, Hayles considers the cognitive ability of technology to be a *nonconscious cognitive*. In humans, capable of higher-order cognition, recognizing patterns can be done consciously or nonconsciously, the latter being a process that is "constantly in motion, reaching metastable states as patterns are discerned and further reinforced when temporal matching with the reverberations between neural circuits cause them to be fed forward to consciousness" (Hayles, p. 24). However, in other agents where

cognitive levels are lower, such as in plants, nonhuman animals, and technologies,

nonconsciousness still continues to recognize patterns and react accordingly. Hayles posits:

> The information may be the sun's angle for trees and plants, the location of a predator as
> a school of minnows darts to evade it, or the modulation of a radio beam by a radio-
> frequency identification chip that encodes it with information and bounces it back. In this
> framework, all these activities, and millions more, count as cognitive. (p. 26)

Hence, cognition is not limited to biologically-living entities and can be utilized by technology in

ways that help to advance its designed purpose. This is an important aspect of technology for

science literacy, because, as Hayles argues, "Analyzing these effects [of technology] opens a

window on how the interpenetration of technical and human cognition functions to redefine the

landscape in which human actors move" (p. 142).

Technological Species

Who sets the moral limits for what research is considered beneficial and which is

potentially detrimental? *Scientists* play with research and technological innovations as if they are

toys for their own amusement. Without regard to consequences of innovation and invention,

Science creates weapons of mass destruction, antibiotic resistance bacterium, and the threat of

individual identity being exposed to everyone with an internet connection. Dyson (1979) writes:

> Science and technology, like all original creations of the human spirit, are unpredictable.
> If we had a reliable way to label our toys good and bad, it would be easy to regulate
> technology wisely. But we can rarely see far enough ahead to know which road leads to
> damnation. Whoever concerns himself with big technology, either to push it forward or to
> stop it, is gambling in human lives. (p. 7)

The innovation of technology through *Science* is largely undemocratic, protected behind closed doors and code-word clearance. When the technology is revealed to the general public, such as rocket technology, there is no debate about the moral implications of developing such technology. Instead, as if it is a courtesy, information is released in an effort to pretend like the public is well informed and ultimately supportive of these new technologies. Without *science* literacy this may be true, most of the public sees militaristic *Science* as a way to strengthen national defense and not arm imperialistic agendas. Most *Scientists* may believe in their research as being patriotic or for the common well-being, and when they see their work used in dreadful ways their true intentions begin to show through. Consider as an example German chemist, Otto Hahn who was part of the team to discover nuclear fission. Dyson writes, "[Upon] the discovery…1938 [Otto] had no inkling of nuclear weapons…When the news of Hiroshima came to him seven years later, he was overcome with such grief that his friends were afraid he would kill himself" (p. 7). I'd like to think that most *Scientists* are like young children when playing with technology, destructive maybe, but that is not their intention. Unfortunately, evidence points towards intentions to develop technologies that earn profits, without regard to how the technology will be used or who will be affected. Further, public debate can be absent in new technologies under the image that the *Science* is too pure and cannot be discussed with individuals who do have the correct level of credentials to speak of such things. Dyson adds, "In the long run, the technological means that scientists place in our hands may be less important than the ideological ends to which these means are harnessed" (p. 7). Therefore, building *science* literacy requires us to gain new perspective on *Science* and technology, how it is developed, and how it can be utilized in both positive and negative ways.

A main component of society where ignorance is abundant and flourishing, is through technology. The lure of technology is seductive. As consumers, the accumulation of technology provides a sense of pride, elitism, and importance. We convince ourselves that possessing the newest "tech" somehow makes us noticeable as part of the "in-crowd", the "top dogs", the "VIPs". As people, technology has become an extension of the very things that define us as human: from social interaction, to acquiring goods, working for a living, and love. Technology is also oppressive. Weaver (2004) writes:

> As the unnatural becomes the privileged and powerful, members of the post-human generation with their implants, memory drugs, and prostheses are the ones who are prepared for the future. Those…who are able to cosmetically alter their bodies, learn at the speed of computer chips, and turn a disability into an advantage will be the leaders of tomorrow's corporations, political parties, and dissident groups. They will create an artificial world that is more real, and more privileged, than the "natural" world. Those…who are unable to alter their bodies…enhance their learning abilities, or benefit…with a prosthesis will be the new urban and suburban poor, relegated to the unskilled and underpaid jobs and lifestyles of the future. (p. 30)

Those who cannot possess certain new technologies are ridiculed and treated as if they are part of a lower class of human. As teachers, we regularly require students to check class websites, calendars, online-homework, and other digital environments to remain up-to-date with course expectations, but some students do not have access to the internet, or have devices that can connect to the internet, or, since the growing number of digital platforms compete in compatibility with specific operating systems, the students do not own the right technology to access certain file formats. Therefore, technology creates a lower-class of sorts by separating

those with access from those without. Learning is also becoming more dependent on technology as the traditional "tech" of the textbook is being replaced with digital, interactive versions of textbooks. No matter the use of technology, without a critical analysis of how much humanity depends on technology we are subjected to its control and its forced evolution of human dynamics. Therefore, the development of a *science* literacy as a tool for analysis of the technological landscape is a necessary component to *science* literacy as a whole.

Our access to information has grown due to the plethora of technological delivery systems. Though access to information is important for an informed democracy, such accessibility is also subject to the spread of false information. After all, truth-by-consensus is all that is needed to give something the perception of being true. Collins (2000) writes:

> The growing influence of television, radio, movies, videos, CDs, and the Internet constitute new ways of circulating controlling images. Popular culture has become increasingly important in promoting these images, especially with new global technologies that allow U.S. popular culture to be exported throughout the world. (p. 85)

This makes the reach of ideals and prejudices far greater than what was previously available throughout history. Most information is delivered unfiltered and un-reviewed, breeding doubt, uncertainty, and conspiracy. By allowing technology to become so abundant in its modes of access, we have "plugged in" to the world instead of experiencing the world. This has both negative and positive consequences. For instance, I can now access images of artwork that were once only available in museums. Zuern (2013) posits, "With the emergence of the Internet…and the World Wide Web…the computer screen…took on its present role as a powerful medium for the production and reception of works of art of all kinds" (p. 256). However, the negative consequence of such an opportunity would be that there is no longer a need to go to the museum

and experience the artwork directly. Technology has connected us to the world while simultaneously disconnecting us from it, and we must be careful how we handle this new mode of living.

Access to information by using any number of mediums is not the only factor that has driven techno-human evolution; equally as significant is the immediacy to access of information. At any given moment I can quickly glance at my cellular device and get access to anything I desire, from referencing the meaning of certain words in an online dictionary, scores to any sporting event, TV shows and movies, or a concoction of anything else of desirable interest. Hayles (2012) reflects on this accessibility:

> I can access national news, compare it to international coverage, find arcane sources, look up information to fact-check a claim, and a host of other activities that would have taken days in the pre-Internet era instead of minutes, if indeed they could be done at all. (p. 2)

At first, to a generation that did not grow in such abundance of access, these opportunities are supplemental to the normal way of things. If we are not careful, if we are not conscious of the evolving state of normal, we become dependent on this access to the point where we can feel lost in its absence. Hayles continues,

> Conversely, when my computer goes down or my Internet connection fails, I feel lost, disoriented, unable to work – in fact, I feel as if my hands have been amputated. Such feelings, which are widespread, constitute nothing less than a change in worldview. (p. 2)

This change is more than just an adjustment to a new normal, but a voluntary ignorance to surrender one's self to the gods of technology. We know the world continues to turn when we move away from our technologies, but that does not stop us from the feeling that something is missing or that we are somehow missing out on the events of the world. To wield *science* literacy

is to challenge the modes of control over people's lives, and the domination of technology is no exception.

Another form of technology that Hayles (2017) cautions against is computational media. According to Hayles, "Computational media are distinct...because they have a *stronger evolutionary potential* than any other technology, and they have this potential because of their cognitive capabilities, which among other functionalities, enable them to simulate any other system" (p. 33, emphasis included). Being computational media refers to a technology that is built and designed to make computations based on incoming information, sort the data, and develop responses appropriate to the parameters of its environment. This ability to compute is not unlike the conscious cognitive capabilities of humans, the main difference being the intense velocities at which these technologies can compute compared to human computational capabilities. Further, computational media can be interpreted as an infectious bacterium, where its ability to evolve and simulate other systems makes it ideal for the incorporation, the penetration into our lives. Hayles posits:

> Fueled by the relentless innovations of global capital, computational media are spreading into every other technology because of the strong evolutionary advantages bestowed by their cognitive capabilities, including water treatment plants and transportation technologies but also home appliances, watches, eyeglasses, and everything else, investing them with "smart" capabilities that are rapidly transforming technological infrastructures throughout the world. Consequently, technologies that do not include computational components are becoming increasingly rare. Computational media, then, are not just another technology. They are the quintessentially *cognitive* technology, and

for this reason have special relationships with the quintessentially cognitive species,

Homo sapiens. (p. 34, emphasis included)

For this reason, understanding technology, its cognitive and computational capabilities, is an

essential layer in *science* literacy. To effectively develop and more importantly control these

technologies we must be aware of the effects technology can have as it becomes more prevalent

in our lives. "Given that the cognitive capabilities of technical media are achieved at

considerable cultural, social, political, and environmental costs, we can no longer avoid the

ethical and moral implications involved in their production and use" (Hayles, p. 35). As is the

argument that *science* has become too important to be left to *Scientists*, so too has technology

and must be part of a *scientifically* literate dialogue and debate.

Consider as an example Hayles' (2017) discussion of the shift from human-machine

interaction to machine-machine dynamics of the stock market. As technology advances, it gains

the capabilities to surpass human abilities. Because of this evolution, stock market kinematics

has moved to more cognitive, autonomous systems that can conduct trading at speeds not

possible for human traders. "Combined with faster processor speeds, vast increases in computer

memory, and fiber optic cables through which information travels at near light speeds," Hayles

writes, "[high frequency trading] has introduced a temporal gap between human and technical

cognition that creates a realm of autonomy for technical agency" (p. 142). The desired effect is

efficiency, split-second action, and to simplify the work for humans. In order to function with

such effectiveness, the technology runs on programming that adapts to situations to make

decisions, Hayles' *nonconscious cognition*. Hayles continues, "Within the space of this

'punctuated agency,' algorithms draw inferences, analyze contexts, and make decisions in

milliseconds" (p. 142). Such autonomous systems, however, operate at such lightning-fast speeds

that in an environment such as the stock market, their reaction to small value fluctuations can lead to high volume trades which can cause stock values to spin out of control. Some stocks may crash, some may sky-rocket, but overall these autonomous systems are in control of the economic foundation of our society. "The predominance of dueling algorithms has created a machine-machine ecology that has largely displaced the previous mixed ecology of machines and humans, creating regions of technical autonomy that can and do lead to catastrophic failures" (Hayles, pp. 142-143). Simply understanding technology is not a safeguard against its destabilizing capabilities, rather understanding our reliance on technology identifies the broader spectrum of which the human-machine ecology exists, and how we should be cautious with our *Science* in developing such technological agents.

Digital Self, *Science* of Man and Machine

In May of 1989, popular culture was introduced to an alien race known as the Borg in the fictional universe of *Star Trek.* The Borg were a collection of cybernetic organisms that implanted small machines into its host which forced the carrier to "assimilate" to the Collective, the hive mind to which all Borg beings were connected. Though in the fictional universe the Borg appeared as an imminent threat, one in which "resistance is futile," the Borg represented a shift in humanity, one where human was melding with machine. Weaver (2010) refers to this as the posthuman, where technology and humanity have fused in order to enhance human capabilities, or to simply survive. In *Star Trek*, the Borg is the enemy, but in the real world we yearn for connections with and through technology. Turkle (2011) writes, "People love their new technologies of connection. They have made parents and children feel more secure and have revolutionized business, education, scholarship, and medicine" (Chapter 8, "Always On," para. 5). Though *Scientists* may develop these technologies for monetary reasons, they definitely know

how to exploit the desires of the larger population by providing these means of connections within a digital space. "Technology enchants," writes Turkle (2016), "It makes us forget what we know about life" (p. 23). Escaping the assimilation with technology, avoiding the transition of the posthuman is not necessarily the intent of *science* literacy, but to proceed with caution as technologies become increasingly more involved in our humanity and so we do not forget about life.

Biologists and anthropologists argue that a major characteristic of *Homo sapiens* is in their tendency to build broad social networks. Human migration throughout history more often shows large group movements and seldom shows evidence to the contrary. Even in modern society there is a subtle expectation of one another to be part of a social group; we promote the importance of family and friends, being social with work colleagues, or getting involved in communities. In fact, individuals who isolate themselves are typically seen as abnormal, bullied, or avoided altogether. In schools, individuals who appear to isolate themselves are concerning and are usually labeled quickly as potential problem children. Turkle (2001) argues, "Research portrays Americans as increasingly insecure, isolated, and lonely" (Chapter 8, "The New State of the Self: Tethered," para. 8). Part of the explanation for such a shift in social bonding lies in the digital worlds we are able to create for ourselves. Turkle (2016) posits, "Virtual space is a place to explore the self" (p. 6). This space allows for the individual to experiment with their identity and who they socialize with. According to Turkle (2016):

> We hide from each other even as we're constantly connected to each other. For on our screens, we are tempted to present ourselves as we would like to be. Of course, performance is part of any meeting, anywhere, but online and at our leisure, it is easy to compose, edit, and improve as we revise. (pp. 3-4)

We may appear to become increasingly isolated, but for a lot of those individuals it is not the physical reality where they choose to exist, but within the digital one. The creation of digital avatars within life-simulation "games" has become increasingly popular and offers new modes of human interaction. Turkle (2011) adds, "It is not uncommon for people who spend a lot of time…in role-playing games to say that their online identities make them feel more like themselves than they do in the physical real" (Chapter 8, "The New State of Self: From Life," para. 4). Turkle elaborates on this idea in reference to the game Second Life, which allows players to not only play a game, but to exist in a literal second life where players go to virtual bars, go on virtual vacations, send their avatars to work where they can earn real money, meet other avatars and have relationships, get married, and start families. Perhaps this shift in acceptable modes of interaction is not entirely a negative thing, but any paradigm shift should be approached with caution and certainty.

There is an inherent voluntary ignorance to the lure of the second life inside a digital environment. The construction of such a space promises users the opportunities to become all things the real world denies them to be. Turkle (2011) argues:

> Connectivity offers new possibilities for experimenting with identity and, particularly in adolescence, the sense of a free space…This is a time, relatively consequence free, for doing what adolescents need to do: fall in and out of love with people and ideas. Real life does not always provide this kind of space, but the Internet does. (Chapter 8, "Always On," para. 6)

I may be biased here, but I personally benefited from this freedom of the digital space to lower my reservations and be whomever I wanted to be. That confidence led me to meet new people across the country, one of which lived roughly 750 miles away, across three states, that

eventually became my wife. However, at the time I met her I obviously did not know I would

one day marry this person, but I realized that I had the opportunity to create whatever online

presence I wanted to; and doing so effectively cut me out of the real world. I didn't make new

friends when I entered high school, I didn't get involved in clubs or many extracurriculars aside

from a few sports. For all intents-and-purposes, I was a loner, too scared to attempt the level of

confidence to "real" people that I effortlessly displayed in the online space. I'll argue, however,

that I was able to develop a certain *science* literacy because I was able to eventually recognize

the online space for what it was, just another medium to connect with people I knew in the real

world across great distances. I was therefore able to remove my fake identity and rejoin the

physical world as my main mode of social interaction. Others are not so fortunate.

The seductiveness of such endless possibilities is vulnerable to exploitation. The

eagerness to join a digital world lowers the guard of how much real information is shared within

this space. Zuern (2013) argues, "Individual users of these technologies remain vulnerable to the

consciousness-shaping influence of the technologies themselves" (p. 263). Therefore, the need to

stay involved in the digital world may require the user to provide personal information, which

because the desire to be in the digital world is so intoxicating, the user may be influenced to

release such information without hesitation. The machine then is in control, both by design and

because of the voluntary ignorance of the user to choose to ignore the warning signs and go all-

in.

While the modern world runs on digital information, all individuals have virtual

portfolios filled with data that effectively identifies them. In this scenario, all things are reduced

to data. The digital world becomes so encompassing that it can recreate every aspect of the

physical world by just running the right permutations and combinations of data. Lyotard

(1979/1984) refers to this idea as the "computerization of society" which Lyotard suggests:

> It could become the 'dream' instrument for controlling and regulating the market system,
> extended to include knowledge itself and governed exclusively by the performativity
> principle. In that case, it would inevitably involve the use of terror...it could also aid
> groups discussing metaprescriptive by supplying them with the information they usually
> lack for making knowledgeable decisions. (p. 67)

If the information/data is left unmonitored, it is taken by data *Scientists* to be used in some way

that benefits the entity behind the *Scientist*. Therefore, *science* literacy must act in ways that limit

the exploitation of data and help determine the reason the data exists in the first place. Bowker

(2013) argues:

> If data are so central to our lives and our planet, then we need to understand just what
> they are and what they are doing. We are managing the planet and each other using data –
> and just getting more data on the problem is not necessarily going to help. What we need
> is a strongly humanistic approach to analyzing the forms that data take; a hermeneutic
> approach which enables us to envision new possible futures even as we risk being
> swamped in the data deluge. (pp. 170-171)

The humanistic/hermeneutic approach Bowker suggests is equivalent to my proposal of a *science*

literacy approach. Who and What the data is for are important questions not being asked of

enough data collection centers. Some arguments for data collection suggest that it is being used

to provide more relevant experiences in the online space, or to maintain security, or be used with

advanced algorithms to find love. These technologies that mine this data are abundant, yet subtle.

They provide numerous benefits while collecting information users may not have knowingly

agreed to give up, or in some instances knew but did not care (voluntary ignorance). Drucker (2013) posits, "Problems of technology, concealed in the apparently mechanistic issue of design, turn out to be a Trojan horse in which the problems of philosophy make their stealth entry into our guarded precincts" (p. 77). Technology can be the maker of ignorance, a *Science* that exploits the individual. It can also unmake ignorance, if the user has the *science* literacy equipped to question it. Lyotard continues, "The line to follow for computerization to take the [beneficial path and not predatory one] is, in principle, quite simple: give the public free access to the memory and data banks" (p. 67) and therefore allow open debate on what data is to be collected and why.

Human/Nature

The intersection of humans with nature is a curious place. We are a species that can never observe nature, for in the act of observing we have effectively altered the environment, no longer making it "natural". Human interaction with nature therefore can be summarized in one word: manipulation. Though humans are a part of nature, they manipulates the natural environment to suit their needs, and with the belief that it is his right to do so. We have removed ourselves from nature and by doing so have changed our perception of nature from being a part of us to being an opportunity for exploitation. The environment or Nature (often referred to in the feminine) exists for the desires of humans, to be exploited for its resources. Harding (2006) posits, "How we interact with nature both enables and limits what we can know about it" (p. 141). In most situations, we limit our understanding of nature to be within the boundaries of our intent and therefore do not appreciate the full capacity of the natural order. Further, the intended use of nature is rarely the manifestation of the common person's desires and is more guided by socio-political agendas. I have argued previously how scientific policy formation does not belong

outside the realm of public debate (Chapter 1) and the utilization of the environment is no exception.

The use of nature is also far reaching, extending beyond the capitalistic desires of Western societies. In other areas around the world the manipulation of nature is influenced by desires to accumulate power, fight wars, and claim territory. Further, the world population is growing exponentially and has put a significant burden on natural resources. "Such problems" argues Parker (2012), "typically cross not only state and national borders, they also blur the lines between nature and society; between economics and culture; and among various areas of political, professional, and academic expertise" (p. 2). Numerous policy shifts occur to keep pace with growing dependency on natural resources in an attempt to sustain a quality of life. In most cases however, the sustainable policy development is more for elite areas where the monetary resources are plentiful. Eventually, I argue, high socio-economic status will mean more than just excessive wealth; being part of the elite will mean access to the necessities for life: food and water. Harding (2006) empathizes, "The risks to life and health modern Western sciences and their technologies enable…all have their worst effects on the already most vulnerable of the world's citizens" (p. 30). Significant change is needed in the procedures of environmental policy formation and therefore requires not just a *scientifically* literate population, but also a population that is sustainably-*scientifically* literate. Therefore, how we interact with the world is determined by the *scientific* literacy we possess. My vision of such sustainable-*science* literacy is similar to what Hayles (2017) argues should be the human actor in the world:

> Alert and responsive, she is capable of using reason and abstraction but is not trapped
> wholly within them; embedded in her environment, she is aware that she processes
> information from many sources, including internal body systems and emotional and

affectual nonconscious processes. She is open to and curious about the interpretive

capacities of nonhuman others, including biological life-forms and technical systems; she

respects and interacts with material forces, recognizing them as the foundations from

which life springs; most of all, she wants to use her capabilities, conscious and

nonconscious, to preserve, enhance, and evolve the planetary cognitive ecology as it

continues to transform, grow, and flourish. (pp. 63-64)

Thus, *science* literacy opens a consciousness to the interaction we have with all things around us,

including our intersections with human-human relations, human-machine technics, and human-

nature ecology.

Environmental *Science*

The growing dependency on multiple forms of technology also has significant effects on

the environment. According to Harding (1998),

[The environment] arrives from a different set of deployments in discourses about the

surroundings with which humans regularly interact in daily subsistence struggles, that can

be appropriated for multinational corporations' purposes, that can be destroyed by human

arrogance, greed, and carelessness, that must be sustained if human and other forms of

life are to survive. (p. 87)

As more and more technologies are developed, the manufacturing processes pollute the

environment by expelling harmful gases into the atmosphere, polluting rivers with contaminants,

and the products can also expel harmful chemicals as they are used by consumers. Even

governments exert dominance over the environment to manipulate its resources for its own gain.

This makes the major argument involving humans and nature about whether humans have played

a role in global warming. This is not an issue that I wish to argue either way for, but rather use

science literacy to understand why there is an argument at all. The pure *science* tells us that certain elements and molecules in our atmosphere can absorb heat better than others. The process is rather simple: the sun warms the earth, the earth radiates heat back towards outer space, the carbon dioxide in the atmosphere absorbs some of that heat while the rest escapes, and therefore keeps the planet a little warmer when the sun returns the next day. This is actually a welcome process since it helps keep the earth habitable at night instead of having temperatures plummet to levels equal to the vacuum of space. The problem is that the more carbon dioxide that is in the atmosphere, the more heat is retained and the more the earth is warmed when the sun returns. After compounding these effects for decades, coupled with continuous carbon dioxide increases in the atmosphere and eventually the earth warms enough to melt glaciers and the polar ice caps. The melting releases more fresh water into the oceans which affects global sea temperatures, which in turn disrupts global oceanic currents and ultimately weather patterns. The chain reaction of events is dizzying, but more importantly is undeniable; each step is a logical progression of "if-then" statements. With such obvious causations how has global warming become a topic of debate? If humans are responsible for the increasing levels of carbon dioxide, then humans are the fuel behind climate change. Considering most carbon dioxide emissions come from big global businesses such as oil, car manufactures, the tobacco industry, and the coal industry to name a few, reacting responsibly to global warming means hurting the bottom line for these businesses. Que the manufacturers of uncertainty and the makers of ignorance.

Denying the *science* of global warming is hardly the position of most political debates; instead most disagreements center on whether or not humans are indeed responsible. If we are, we must change our habits, our dependence on fossil fuels, and move towards clean energy production. If we are not responsible, then all is fine in the world and we can continue our

established way of life. To begin shaping the public perspective, *Scientists* begin to control the

mediums of communication. Information on human-caused climate change is typically restricted

to pure *scientific* journals written by individuals with the expertise to effectively speak of such

things. Further, access to these pure *scientific* journals is scarce to the general public and are

usually only available at the highest levels of research institutions and universities (Ward, 2002).

Only those with particular high levels of *science* literacy know where to find information and

how to interpret the information to favor one position over another. Unfortunately, individuals

with high *scientific* literacy represent a small minority in the comparison to the rest of the

population.

The United States began to make global warming a political topic rather late in the

twentieth century (Oreskes & Conway, 2008). The Marshall Institute was a think tank

established during the Cold War to help provide research and information to the general public

about the government's intention to build an anti-missile defense shield. Public perception of the

project made its funding difficult to justify, resulting in the commission of former physicists to

head-up research that could help persuade the public's perspective to align with the military

industrial complex's desires. When the Cold War ended, and the anti-missile project was no

longer needed, the institute was tasked to shift its attention to global warming, among other

national issues (such as the link between tobacco use and cancer). Lahsen (2008) argues, "While

the Marshall Institute's internet website claims that the institute produces reports that are

objective and unbiased, Marshall Institute analyses consistently promote unregulated free-market

forces, military defense technology, and nuclear power, while opposing environmental

regulation" (p. 207). The Institute took the position that, according to Oreskes and Conway, the

science of global warming was "uncertain, incomplete, insufficient, or otherwise inadequate" (p.

60). To convince the general public that climate change was not based in facts but rather

conjecture, Oreskes and Conway continue:

> Its spokesmen and members have argued that there is no proof that global warming is real
>
> or, if it is real, that there is no proof that it is caused by human activities or if it is real and
>
> anthropogenic, that there is no proof that it matters. (p. 60)

Further, since pure *scientific* journals are not mainstream, these manufacturers of uncertainty

know to use modes of communication that are readily accessible, such as appearing on TV talk

shows, radio shows, and writing for popular (not necessarily science-based) publications. The

spread of ignorance is profound and difficult to oppose since the vast majority of individuals lack

the *science* literacy to filter out nonsense. According to Oreskes and Conway, "Polls also show

that Americans have been consistently less concerned about global warming than citizens of

other nations" (p. 75), since the most effective action to fight it lies in government regulations of

the biggest polluters. This is why most anti-global warming rhetoric is associated with the

traditionally anti-regulatory positions of the American Republican Party.

Global warming and climate change have also been labeled as failed attempts to argue

against capitalism. Oreskes and Conway (2008) write, "Throughout the literature of climate

change denial, a recurrent theme is that environmentalists are motivated by a desire to bring

down capitalism and to replace it with socialism or communism" (p. 77). The threat of new

world-government built on environmental consciousness was too socialized for Western

governments to entertain. Oreskes and Conway continue,

> If global warming were proven true, then government interference in free markets would
>
> necessarily follow. Thus, [*Scientists*] *had* to fight against the emerging consensus, either

by challenging the scientific evidence directly or by creating the impression of ongoing

scientific debate. (p. 79)

In fact, author Michael Crichton's *fictional* novel *State of Fear* suggested an eco-terrorist group

would plot mass murder and blame it on global warming in an attempt to put serious attention on

it. Though the novel was a work of fiction, it included many pieces of *Scientific* information that

contradicted global warming evidence. Crichton was even called on to testify before Congress as

a witness to argue against global warming (Oreskes & Conway). The attempt to use celebrity-

status as an equivalence to expertise is of course not a new tactic. Pseudo-experts present a real

danger to the legitimacy of *scientific* work and the consequences of irresponsible-*Scientific* work.

In the history of global warming debate there lies an interesting counter-argument to the

pseudo-expert label. The Marshall Institute, which is the primary source of manufactured

uncertainty and constructed ignorance in the global warming debate, was being led by Ph.D.

physicists, referred to as "the trio" (Lahsen, 2008). These physicists were, Frederick Seitz,

Robert Jastrow, and William Nierenberg. Each were prominent in their respective fields within

physics and contributed to numerous projects including: head of the theoretical division of

NASA's Goddard Institute for Space Science, science advisor to the Defense Science Board and

NATO, and the Manhattan Project. Lahsen (2008) writes, "These scientists cannot be dismissed

as lesser or 'pseudo-scientists'...they are extraordinary accomplished scientists who throughout

their careers have served on a large number of governmental panels and influential scientific

advisory committees" (p. 209). Since the American political system is so divisive, global

warming can become ammunition in political stances and ideologies. Lahsen posits, "Like

others, politicians often select scientific expertise on the basis of pre-established political

agendas" (p. 207). Especially in the political debate of global warming, the Marshall Institute

and its trio helped guide the discussion towards doubt of science and could do so because it had the experts to make claims. Lahsen continues, "The trio undeniably forms an influential – and also the most prestigious – faction amount US contrarian scientists with respect to climate change" (p. 207). Hence, these trained experts move from *scientists* to *Scientists* as they exploit the tools and error-correcting mechanisms of *scientific* inquiry and build *nomological* machines (see Chapter 3) to generate just enough contradictory data to make the *science* of global warming uncertain. According to global warming deniers and the trio, Oreskes and Conway posit, "The true goal of the environmentalist movement was the redistribution of wealth…[this] is why environmentalists are so enamored of international treaties and regulations: they view them as levers toward achieving a new world order" (p. 77). Therefore, politicizing the environmental issue allows *Scientists* to alter the perception of who the true victims of global warming are, corporations, free markets, and American capitalism.

The question then, is why did these *scientists* become *Scientists*, and argue against the *scientific* consensus? Lahsen (2008) suggests that the change occurred out of a reluctance to relinquish the prestige that came from being prominent physicists. According to Lahsen, around the 1970s when the general population's perception of science shifted from the production of things (*Science*) to environmental consciousness and peace movements (*science*), prominent physicists such as the trio began to lose funding, prominence, and were no longer uncontested voices in policy-making (p. 210). The trio were then eager to support any position that would give them their prestige back. Further, when politicians began using their political platforms to debate *science*, the trio were enthusiastic to join the cause. In order to not segregate themselves from the scientific community entirely, they did agree about some irrefutable facts, such as a need to move away from fossil fuels and incorporate new technologies. However, while climate

change sympathizers would argue in favor of "raising environmental concern and instigating governmental intervention to trigger and nurture innovation," according to Lahsen, "the trio appears to believe that the technological innovation will happen without such intervention, a stance that harmonizes with the conservative movement's general anti-regulatory agenda" (p. 211). This capitalization of the environment is the core argument against environmental consciousness and needs *scientifically* literate public debates.

Environmental *Science* is not limited to the actions that capitalize on the environment, but also about the battle between nations over who has the ownership to utilize the environment's resources. Ward (2002) highlights conflict between Israel and the Arab League in the Six Day War of 1967 as an example, where "the Arab League, angered at Israel's construction of its National Water Carrier, which had appropriated much of the water of Jordan River for use in Israel," began to construct their own means to divert water from the Jordan River to their land, which was then attacked by Israel (Ward, 2002, pp. 187-188). Though the fighting among these nations has been fueled by more than just water, access to water created new conflicts. Ward posits, "A river is without nationality…Almost half the earth's land lies in river basins shared by at least two nations, and 80 percent of the world's available fresh water flows through international river basins" (p. 188). Yet, around the world there are drought-stricken areas that are in proximity of fresh water, but the river is "claimed" by another nation's government. Equally concerning is the ratio of available resources to population size. According to Ward:

> As humanity grows thirstier in the earth's driest places, or is threatened by flooding rivers and encroaching seas in wetter ones, the steady rise in population puts stress on the land and the water. It took all of history up to 1830 to put a billion people on the planet but only one hundred years to add the second billion. The third arrived in just forty-four years

and the most recent billion came in a scant twelve years. Women are having fewer babies in many places and there is real hope that the population will stabilize in this century, but there are now six billion of us and we add the equivalent of a New York City to the planet each month. Ninety million people a year. Think of a million lives lost in a famine or war – those numbers are replaced in four days. (p. 3)

At the time of Ward's book, a quick Google search indicates that the world population was at 6.3 billion people. In 2018 the population grew to 7.6 billion, showing that Ward's "real hope" for stabilization has not come yet as the most recent billion people were added in just 13 years. The strain this puts on resources in different parts of the world have already been clearly identifiable. Ward continues, "The Middle East alone is home to five percent of the world's population and only one percent of its renewable water resources" (p. 188). While the reality of diminishing natural resources compared to population growth is more of an environmental *science* issue, restricting access to resources because of social and cultural differences is a *Science* issue.

One of the largest uses of the environment is agriculture. Agriculture uses the most amount fresh water everywhere in the world and is important to sustain food sources for the world's population (both meat and vegetation). Because of the world's dependence on its products, agriculture has been absorbed by most of the world's governments in order to maintain its control, distribution, and its economy. The *scientists* of agriculture, farmers, know how to cultivate the land, how to adapt to weather, and when to sow and harvest. Therefore, it is necessary to argue in favor of the farmer-*scientist* in order to appreciate their expertise in their field, to give them a credible voice in *Scientific* policies and agricultural planning. Despret and

Meuret (2016) describe extinction as a cause of what I argue is *Scientific* interference:

> What the shepherds [farmers] were confronted with, and what they resisted, were particular forms of extinction: not the form that makes a species, in the sense of quantifiable biodiversity, disappear but those that make worlds die, worlds that were hitherto shaped and characterized by practices, by modes of inhabiting, by landscapes that are no more. (p. 28)

From this perspective, Despret and Meuret argue that extinction occurs when a given species is removed from their natural world and placed within a restrictive one. Despret and Meuret elaborate further, "Extinction begins when the ways an animal composes the world and composes with the world are ended, when the ways he or she makes a world exist, according to the ways his or her ancestors had created it, have disappeared" (p. 29). Farmers, then, are the protectors from such situations. The farmer understands the necessity for their animals to graze open spaces, rather than be restricted to small pens and cages. What makes farmers *scientists* is not in their ability to control the land, but rather to understand the environment so as to nurture its natural abilities to produce. Despret and Meuret continue, "these shepherds [farmers] cultivate an aesthetic in the sense of a practice that learns to compose with the world in various ways...They invent ways of inhabiting a world that is being destroyed while resisting, locally and actively, this destruction" (p. 30). The farmer-*scientist* then is the master of his or her domain, having learned through experimentation and observation how to best work with the environment instead of making the environment suit his or her needs.

The farmer-*scientist* may possess the learned expertise of agriculture, but the government's agricultural-*Scientists* attempt to manipulate agricultural practices to benefit the government before it is distributed to the people. Ward (2002) writes, "[Governments] have

overlooked the main ingredient in making any irrigation system function – the farmers on whom any system ultimately depends" (p. 131). For this reason, projects to cultivate land that is otherwise uncultivatable are commissioned without regards to the economic, health, or environmental consequences, moreover, without consulting with farmer-*scientists*. In some instances, national policies in regards to agriculture have either evicted farmers and their livestock from grazing certain lands, or in an attempt to satisfy the growing demand have assigned multiple farmers to grazing areas. The results then are overgrazing and damaged land, to which Despret and Meuret (2016) argue, "is why shepherds [farmers] are now called to the rescue, to limit encroachment dynamics and to re-create, through targeted grazing, a more diversified...landscape" (pp. 33-34). Understanding how the environment works best in its natural capacities is the knowledge of *scientist*-farmers and is too often threatened by those that wish to capitalize on those natural qualities to produce unnatural quantities, the agricultural-*Scientist*.

Even though agriculture accounts for most of the world's fresh water usage, the process of diverting water to create artificial or commercially viable agriculture is a dangerous gamble. The farmer-*scientist* understands the limits of the environment and works with those limitations rather than attempt to work around them. In contrast, the agricultural-*Scientist* believes himself or herself capable of such manipulation, either choosing to ignore the potential consequences or innocently unaware of them. The results could be devastating, cause conflicts, or lead to irreversible damage to the environment and ecosystem. According to Ward (2002):

> Systems are all too often planned without consulting farmers or studying local systems. Engineers from green, rainy countries have put unsustainable systems in dry, thorny ones, leaving decaying, unworkable canals and heavy debt loads. Health officials in tropical

places have not been included in planning irrigation schemes to prevent waterborne

diseases…Not enough water has been left in rivers for the survival of ecosystems. Worst

of all, governments and builders, in place for the short term, justify projects for short-

term gains and don't spend the money necessary to make irrigation work over the long

haul. (p. 105)

Ward's examples here represent the accidental consequences of government-agriculture but there are also intentional consequences. Many nations use irrigation systems, dams, canals, and other methods to divert resources away from enemy nations, poorer regions, or to simply horde the resources for themselves. Since many nations can border fresh water sources, when one nation decides to build dams and reservoirs which effectively cut off supply to their neighbors downriver, tensions escalate, and wars can break out. Conflicts over natural resources such as fresh water have been occurring for a long time, and the idea of an impending World War over something as taken-for-granted (in privileged countries) as fresh water becomes less of a fiction. Ward posits, "Understanding the complexities of hydraulic control, how and why dams get built, and who builds them, matters more than it ever has" (p. 51). Conscious thinking about access to resources, who controls those resources, and how those resources are distributed are becoming increasingly significant questions. Therefore, we as a species must equip ourselves with the *science* literacy necessary to pose such questions and challenge the hegemonic structures that attempt to control life's necessities.

Environmental *science*

There is a real concern about the amount of voluntary ignorance and manufactured ignorance when it comes to information about the environment. For the individual the environment is too big to comprehend any kind of significant impact, so they choose to ignore it.

Equally concerning, the blind faith that as humans we somehow have the authority, autonomy, and ability to control the ecological environment. Hayles (2017) posits:

> The same faculty that makes us aware of ourselves as selves also partially blinds us to the complexity of the biological, social, and technological systems in which we are embedded, tending to make us think we are the most important actors and that we can control the consequences of our actions and those of other agents. As we are discovering, from climate change to ocean acidification to greenhouse effects, this is far from the case. (p. 45)

Because of humanity's self-perception as intelligent beings, the epitome of Darwin's survival-of-the-fittest, made in His image, there is an inherent belief in humanity's supremacy over all agents within our environment, regardless of the presentable evidence to the contrary. As a population, sustainable practices, responsible consumption, and ethical treatment of others is too politicized, so the information is manufactured to keep the attention away from *science* and towards one another with labels such conspiracy theorists and anti-capitalistic (therefore, anti-American) bigots, or to maintain the image of *Homo sapiens* as the dominant species. There are enough cultural characteristics that we falsely use to separate ourselves from one another, we do not need to add access to resources to that list. Sustainable-*science* literacy is not a different *science* literacy than has been discussed throughout this dissertation. All *science* literacy discussed here *is* sustainable, because no matter what degree of *science* illiteracy is analyzed, it cannot be sustained unless we want a future of justice and equality. Therefore, understanding the environment and how its dwindling resources pose a threat to peoples all around the world is a necessary component of the *science* literacy toolbox.

As demonstrated in the previous section, the diminishing amount of fresh water poses a real danger to the sustainability of life around the world. Ward (2002) argues, "More than half the world's major rivers are either polluted or going dry. Half the planet's wetlands were lost in the twentieth century, and freshwater systems…are losing their ability to support human, animal, and plant life" (p. 3). This is not an argument against global warming, which was highlighted numerously in the previous section. Global warming, while it has a direct effect on the environment, has unfortunately become too political to be environmental *science* and is instead a *Science*. The diminishment of natural resources is undeniable, and it is further undeniable that humans are the cause of it. The unfortunate reality is that humanity had to use natural resources to survive; it is not like consuming these resources was avoidable. However, carelessness, wastefulness, and voluntary ignorance are to blame for the vast depletion of resources over a relatively short amount of time. The privilege of access to resources, like clean water, puts a shield-like bubble around individuals that protects them from knowing how the things they take for granted are scarce elsewhere. The idea that most Americans are in a position to take hot showers/baths daily, turn on lights when it is dark, have three or more full plates of food a day *and* be able to throw whatever was not eaten away are all examples of the carelessness, voluntary ignorance, and unstainable life practices that have to be addressed. Klahr (2012) posits, "Over the course of the next few decades, every academic discipline will have to respond to the paradigm of more sustainable life practices" (p. 19). How we live, not just how we treat one another, but what we physically do each day is going to become more significant than it ever has before.

Recall that *science* is an ever-changing understanding (Chapter 2). Through experimentation and inquiry, *scientists* develop theories which are then tested and lead to results

that can disagree with their original stance. Their understanding, then, changes and how they proceed is very different than how they would have proceeded if they were right the first time. Sustainability is similar, according to Klahr (2012). Klahr argues, "*Sustainability is not a goal, but an endless process of constant implementation, assessment, and readjustment*" (p. 20, emphasis included). Living with sustainable intentions is a process in flux as we reflect on what we have contributed to the greater sustainability ideal. But this is also disconcerting when one considers the position of how he or she has done the responsible, sustainable thing when others have not. Also, individuals may not engage in sustainable practices when they believe that their actions are too small to make a real significance on the global scale. This is why *science* literacy is necessary because it opens the perspective to include more individuals than just one's self. Drewel (2012) writes,

> Sustainability most certainly is linked to the environment and to economic and social factors, but another, often neglected area speaks to our hearts. Sustainability, both as idea and practice, connects to our core values. Sustainability and living in a sustainable manner are important to people; it touches many of us deeply and offers us a way to contribute to our communities in a meaningful way. (p. 242)

With *science* literacy we become compassionate towards others' struggles and situations, and therefore attempt to live sustainable ways of life so that others less fortunate, less privileged may have a chance. This is what enables the *scientifically* literate person to live sustainably, by understanding how important responsible actions can be on a larger scale.

The wastefulness of modern society is due in large part to its economic interests and ambitions. Companies build more factories to produce more goods for consumers, in doing so they dump more pollutants into air and water supplies, build their products using cheaper

materials like plastic and other non-biodegradable substances. As more products enter the

market, consumers discard their old gadgets for new ones effectively putting twice the amount of

polluting materials in the environment. Parker (2012) posits, "Economic, political, and cultural

factors drive changes to the physical environment and affect the earth's natural systems; changes

to those systems in turn force changes – often dramatic and sudden – in the realm of human

society" (p. 2). A sustainable *science* literacy is therefore not limited to the literate person's

sustainable way of living, but also in that person's ability to see the inevitable unsustainable

situation that is emerging as society evolves. The sustainable *scientist* also recognizes the finite

nature of the earth's resources, like clean water. Ward (2002) argues,

> Although this supply of water is largely fixed in amount, a great deal can be done to alter
>
> its location and quality. Our access to fresh, clean water has been radically transformed
>
> by interventions – dams, storages, diversions, overuse, and pollution. The effects of water
>
> use and misuse are, with increasing frequency, felt from their source. Those who believe
>
> the water problems of other areas won't affect them ought to consider that water-short
>
> California produces about half of the United States' fruits and vegetables and much of its
>
> dairy products. We should understand that draining the Everglades has meant less rainfall
>
> for Miami, and that industrial effluent poured into the Rhine in Germany must be cleaned
>
> up in the Netherlands. (pp. 6-7)

The sustainable *scientist* recognizes the effects of voluntary-environmental ignorance and seeks

to challenge the unsustainable practices they encourage. Without a sustainable-*science* literacy,

the cost of harming the environment will inevitably fall on the most vulnerable of people, forcing

them to deal with the consequences of greed and corporate imperialism. Since sustainability is

linked to pollution and growing concern over climate change, then perhaps Oreskes and

Conway's (2008) claim that climate-change deniers' fear that the environmentalist movement is seeking to establish a new world order against capitalism (p. 77) is not entirely misplaced. Living sustainably would require a shift in how we function in the world and would change our habits of consumption; something that capitalism would definitely be threatened by.

If the majority of the world's citizens choose to ignore the environmental *Science* that is generating conflict elsewhere in the world, eventually that conflict will catch up to them. However, choosing to ignore environmental *science* is equivalent to digging your own grave. Though the effects of environmental negligence and ignorance may not be experienced directly by generations alive today, future generations will pay the price. It is only a matter of time before our grape-like earth shrivels up like a raisin, before nations battle for control of whatever is left. Ignoring the *Science* can lead to war-induced destruction, but history has shown that society can bounce back from it. Ignoring the *science* can lead to a future where no society can exist. We must become ever more conscious of the environment around us, recognize and understand the *science* that is telling us how bad things can get, and practice responsible and sustainable consumption if we are to survive.

CHAPTER 6

INVENTING THE FUTURE: CREATIVITY, IMAGINATION, AND *SCIENCE* FICTION

CURRICULUM STUDIES

"I am enough of the artist to draw freely upon my imagination. Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world." – Albert Einstein

"Man cannot discover new oceans unless he has the courage to lose sight of the shore." – André Gide

"Curious that we spend more time congratulating people who have succeeded than encouraging people who have not." – Neil deGrasse Tyson

"If you think education is expensive, wait until you see how much ignorance costs in the 21st century" – Barack Obama

The development of *Science,* its evolution, migration, and utilization can all be traced back to an education that fails to bring students into a dialogue about how *science* can be and is exploited. Further, by not developing *science* literacy students are susceptible to join adult-society as accomplices to the institutions in place rather than present critique and debate towards them. Teaching students to ask effective questions is not enough to build this necessary literacy. The students also need their creative capacities nourished and supported. Without creativity or imagination, expecting students to innovate the future is not a productive expectation. Public schools function on curriculums that effectively reduce the creative capacities of students to almost nothing, which is an appreciated amount by the institutions that want to remain unchallenged and in power. Public schools then become institutions of the corporate state as they force students into one-size-fits-all curriculums where the ability to produce products is valued more than the ability to think for one's self. This chapter explores the need to nourish creativity in school curriculums, especially in *science*, and offers an idea to use *science* fiction as a platform for critical dialogue within such curriculums.

Cultivating the Creative Space: Tending to the Garden

Children are naturally creative and imaginative. When reflecting on my observations of children, including my own and the friends they interact with, I noticed that any object within reach becomes something else entirely in their eyes. My son, for example, can pick up a paper-towel cardboard tube, look it over and it immediately becomes a lightsaber from *Star Wars*. Suddenly he is a Jedi, battling imaginary foes throughout the house. If he is playing with a friend, near the same age, they too will see a lightsaber and react accordingly as if it was really being swung in their vicinity. My daughter will place her diverse population of stuffed animals on the floor, all facing the same direction, towards a microphone. With the addition of a little music, suddenly my daughter has become the biggest pop star in modern music. If she has a friend over it becomes a duet. Through their eyes they see an entire audience out of just a few handfuls of stuffed animals. I do not see a lightsaber or an audience, but I do see a cardboard paper-towel tube and stuffed animals staring lifelessly in a general direction. There was a time when I would have seen the same things my children see; in fact, I can remember times when I *did* see those same things, just not anymore.

This creative capacity within everyone is reminiscent of Harrison's (2008) gardens. Harrison writes of gardens as spaces for creative expression. Understanding gardens from this perspective suggests that those that tend to the garden, the gardeners, are then the nurtures of growth, beauty, and sustenance. There is therefore a hierarchy of gardeners/gardens that exist in education. The students represent a garden, which the gardener (the teacher) must tend to. But there is also a garden within the students, which they must in turn become their own gardeners in order to nourish their own internal fertility (creativity). Harrison writes, "Just as the gardener can cultivate life but not create it, so too the teacher can generate true knowledge but can only foster

the process by which it's born in the student's mind" (p. 65). Therefore, gardening students is an exercise in the nourishment of their creative capacities. The garden itself is creative expression. Therefore, students must be taught how to be gardeners of their own capacities. Harrison posits, "Gardening is an opening of worlds – of worlds within worlds – beginning with the world at one's feet" (p. 30). The use of the garden metaphor is appropriate because educators and reformists are always talking about the *growth* and *development* of the students. Therefore, the process of cultivating growth and development is akin to gardening and the care and attention of the gardener is exactly what students need in an environment trying to dissuade them from their creative capacities.

Before I go too far with the metaphor of gardens, I want to share what I found to be the most apt description for students' creative capacities. Robinson (2017) defines imagination, creativity, and innovation bluntly, "[Imagination] is the process of bringing to mind things that are not present to our senses; [creativity] is the process of developing original ideas that have value; and [innovation] is the process of putting new ideas into practice" (p. 2). Good *science* requires all three; good citizenship relies on all three. Unfortunately, we tend to be educated out of these things by being told how to think, what has value, and what we are expected to make. Robinson writes, "Everywhere I go, I find the same paradox. Most children think they're creative, many adults think they are not. This is a bigger issue than it may seem" (p. 1). Adults are responsible for policy and are tasked with solving problems that have precedence on everyone's lives. If these "problem solvers" are not creative, imaginative, or innovative then they run the risk of solving problems using the same thinking that created the problems. Therefore, it is difficult to approach this issue with a sense of what the right thing to do might be; my education came from the same public institution as most others and I have had my creative

capacities diminished just as much. What I can suggest is the need for creative nourishment, support for imaginative curriculums, and innovative ways for students to express their understanding. Collectively, this represents a *science* literacy curriculum that can shift paradigms.

Nourishing creativity requires an educator to recognize that all students are inherently creative. Robinson (2017) posits, "Everyone has creative capacities. The challenge is to develop them. A culture of innovation has to involve everybody, not just a select few" (p. 3). A creative curriculum allows students to explore and absorb, rather than be forced-fed information which is rung out like a wet rag after the test. Discovery and experience breed deeper understanding and longer retention then conformity. Blades (2001) writes, "Such experiential learning opens the world, presenting a standing invitation to ponder, explore, and understand the effects of reality" (p. 70). This also argues against the typical *Science* curriculums that most are used to. The traditional curriculums, including *Science*, "[Focuses] on content rather than problems," Hayles (2012) argues, "assuming that students will somehow make the leap from classroom exercise to real-world complexities by themselves" (p. 9). The lack of imagination that goes into content delivery teaches students information that is one-sided, argues that all information is ultimate truth, and failure to comprehend the material results in a stunted life.

Nourishing creativity and imagination are not necessarily the task of core contents to spearhead for every child. What is necessary is a rejuvenation of the arts in school curriculums that receive as much emphasis as math, science, and literature. Giving the students opportunities to exert their creativity in an environment that strongly encourages it is severely lacking in the public education system. Further, appreciation of the arts strengthens abilities across the core

subjects. Robinson (2017) argues,

> The sciences and the arts both involve personal passions and both can be highly creative.
> Science as well as the arts can have considerable influence on how we feel about the
> world and on the world we have feelings about. These features of arts and sciences have
> implications for how we should think about creative processes and for how they should
> be provided for in education and training. (p. 160)

The relationship between the arts and *science* should be bridged closer to one another. Thinking *scientifically* is like the artist finding their expressive voice. A *scientist* is an artist of nature, painting pictures to emphasize the world's complexities and aesthetics. Weaver (2010) writes, "[An] aesthetically educated person lives in their era but actively seeks to transform it. They learn to play with the world in order to recreate it…It is a playing that transforms what is into something original" (p. 78, in reference to Schiller, 1965, *On the aesthetic education of man*). This is the idea for building a *science* literacy curriculum, to *scientifically* play with the world in order to recreate it into something fair, just, and original.

Playing with the world returns to the metaphor of gardening discussed earlier. However, being the cultivator of students' capacities is not enough if the students do not develop the desire to be cultivators themselves. Harrison (2008) provides a retelling of Adam and Eve from the Book of Genesis which helps here. Harrison suggests:

> [God] created a naïve, slow-witted Adam and put him in the Garden of Eden, presumably
> so that Adam could 'keep' the garden, but more likely to shield him from the reality of
> the world, as parents are sometimes wont to do with their children. If he had wanted to
> make Adam and Eve keepers of the garden, God should have created them as caretakers;

instead he created them as beneficiaries, deprived of the commitment that drives a

gardener to keep his or her garden. (pp. 7-8)

In this context, we can relate the placement of Adam and Eve in the Garden of Eden to the

students that are placed in our classrooms. By feeding students information and not allowing for

their creative capacities to flourish, those capacities begin to diminish and the students lose the

desire to be cultivators of their own destiny. When Eve engages with the forbidden fruit, the

Bible argues that it began the "fall of man," a descending into mortality and sin. Harrison

however sees the act differently: "It was...an act of motherhood, for through it she gave birth to

the mortal human self, which realizes its potential in the unfolding of time, be it through work,

procreation, art, or the contemplation of things divine" (p. 15). Therefore, it should be expected

of our students to see the potential in their abilities to be gardeners of their capacities, to engage

with the forbidden fruit so that may be exposed to the world that awaits them and be ready to

cultivate it as they desire. Harrison posits, "It was only by leaving the Garden of Eden behind

that [Adam and Eve] could realize their potential to become cultivators and givers, instead of

mere consumers and receivers" (p. 10). It is the task of the teacher then, to act as the gardener

and nourish the growth and development of students so they may use their creative capacities to

recreate the world. This growth is also a *science* literacy, which thrives on creativity and

imagination, much like the gardener can imagine the possibilities of their garden.

In order to recreate the world, *science* literacy needs to be imaginative, in the sense of

Robinson's (2017) definition stated earlier. Creativity may empower individuals to think of a

world worth building, but imagination allows them to see it as real. Robinson writes:

Imagination enables you to step out of the here and now. You can revisit and review the

past. You can take a different view of the present by putting yourself in the minds of

others and can try to see with their eyes and feel with their hearts. In imagination you can

anticipate many possible futures. You may not be able to predict the future, but by acting

on the ideas produced in your imagination you can help to create it. (p. 129)

Imagination, then, is likened to fiction but with important opportunities. Envisioning a future can

help initiate dialogues about the potential of the evolving world, both good and bad. Visualizing

how certain policies today can affect people decades from now is an important debate that

science literacy empowers us to engage in. By critically analyzing the state of cultural disparities,

injustices, and ideologies, the *scientifically* literate individual can imagine a world where those

characteristics are intensified if left untreated, or have diminished if a *scientifically* literate

culture has taken control of policy formation. But such futures are not simply fictions, but

science fictions, which presents an interesting space to consider as a part of a *science* literacy

curriculum.

science Fiction as Curriculum

Using *science* Fiction (*s*F) as curriculum requires a *science* literacy approach to the

benefits of the genre and not just a categorization of plots. I choose to think of *science* fiction

curriculum as *s*F instead of *S*F because the former looks at the genre as a space for conversation

about the human condition, the latter is limited to stories without discourse. In this sense, all

science fiction is either *s*F or *S*F; how we analyze those stories for meaning can potentially

change the signifier from *S*F to *s*F. In the case of *science* literacy and curriculum studies, the

focus then is to only reference those narratives which can be *s*F. For most people, providing an

example of a *S*F story would likely involve alien-human interactions, technology-human

interactions, or humans-in-space plots. But to the *scientifically* literate person, those same stories,

identified as *s*F, provides insight to the human condition, digs into the meaning of the

interactions of characters and how the stories serve as reflections of our own natural tendencies. Even though *s*F is a "fiction", it is created out of something that is not fiction. Haraway (1989) posits, "Both fiction and fact are rooted in an epistemology that appeals to experience" (p. 4). How we experience the world directs how we imagine what the world will become. Of course, since the future does not exist (depending on your metaphysical views) it is automatically fiction. But this does not, or rather, should not be enough reason to not give credibility to an imagined future if it is based on current situations and institutions that effectively govern how human interactions occur. Anijar, Weaver, and Daspit (2004) argue:

> Science fiction can and does provide a medium through which the future of education is
> visualized, through which educators and students can contemplate and reflect on the
> consequences of their actions in this world. Science fiction provides a genre, a medium
> through which the future can be speculatively visualized in the present. (p. 1).

The inventiveness of *s*F is its lure, allowing for the opportunity to discuss with students futures not yet realized that are the results of action or inaction by the population. Using *s*F as *science* curriculum also enables students to use their creative and imaginative capacities inside of the *science* classroom to develop the necessary literacy to envision the future.

How *s*F appeals to the curriculum studies scholar is in its ability to bring the otherwise unnoticed power dynamics to the forefront of conversation. Anijar, Weaver, and Daspit (2004) argue, "science fiction provides both a better description and a better metaphor for human conditions than academic work currently does" (p. 14). This is primarily due to academic projects being designed by special interests and agendas, limiting the full spectrum of observations to a narrowed view that agrees with the status quo. Academic work, therefore, is reminiscent of Cartwright's (1999) nomological machine (Chapter 3), being a set of practices

specifically employed to yield desired results. Conversely, *s*F allows for the imagination to generate all sorts of scenarios that do not exist, or that do exist but too subtly in the modern world for everyone to pick up on. Further, *s*F can act as a goal to develop new *scientific* technologies towards. Roberts (1993) writes, "Not only are science and science fiction parallel, but science fiction shapes the possibilities of scientific vision" (p. 5). Therefore, utilizing *s*F with *science* students can include conversations about where *science* can go in the future in both humane and predatory hands. But to do this requires a *science* literacy that is both optimistic and cautious, not just one or the other.

Some of the most popular forms of *s*F stories involve dystopian futures. According to Penley (1997), "American science fiction generally shows an affinity for dystopian rather than utopian futures, often featuring fantasies of cyclical regression or totalitarian empires" (p. 20). Perhaps it is easier, given the current state of *scientific* illiteracy, or the wide-grip of *Scientific* practices, to believe a dystopian future is more realistic than a utopian one. Anijar, Weaver, and Daspit (2004) posit,

> Militaristic science fiction and post-apocalyptic science fiction act as cautionary morality tales, reminding us of the more horrific possible outcomes of our actions. Science fiction not unsurprisingly is an ethical check, a voice in the wilderness crying out for some form of sensibility. (p. 8)

Developing *science* literacy can see something else in the distance, a future saved by *science*, but it requires more people to be active participants in *scientific* policy formation and debates. According to Schneider (2016), "Some of the most lavish science fiction thought experiments are no longer merely fictions – we see glimpses of them on the…horizon" (Introduction, "Part I", para. 8). Therefore, *s*F puts an image on the horizon that we can either attempt to achieve or

hopefully avoid, but the process requires a *scientifically* literate population to understand how such futures can become reality.

The genre of *s*F also creates reflections of our institutionalized treatment of one another, especially when we believe ourselves to not be prejudice. An alien invasion reflects how we are fearful of the Other, and how we view them as an invasive species. The enemy's leaders tend to focus on the *Queen*, since it is the female's ability to reproduce that poses the greatest threat to humanity's survival. It is natural, almost, to generate such plots because perhaps it is natural for humanity to believe such treatment of the Other and females possible. Anijar, Weaver, and Daspit (2004) write, "Science fiction presents [a medium] in which voices that are too uncomfortable, too marginalized, can speak because of what is not yet there" (p. 14). While *science* may be too important to be left to *scientists*, *s*F is also too important to be left to the *science* enthusiasts and hobbyists. It presents opportunities for everyone to participate regardless of the depth of prerequisite *science* knowledge. The issue is not the availability of *s*F mediums or stories, but to engage more individuals into those stories so they may see a reflection of their communities and cultures and hear the voices of oppressed people, which initially they were unaware of. Briefly, I will demonstrate how *s*F combines with a critical-cultural studies lens to highlight dialogues about race and gender in *s*F stories.

Race in *science* Fiction Curriculum

Chapter 4 discussed how *science* literacy can draw attention to the institutionalized racism that exists throughout American culture as well as globally. Further, *Science* was discussed as a mechanism to maintain this institutionalization by attempting to use manufactured uncertainty and pseudo*science* to provide misinformation about racial differences. To move beyond the conversation about how racism exists currently or how it was practiced in the past, *s*F

allows a space to discuss what can happen to racism in the future, pending how it will be dealt with. Lavender (2011) argues, "[Science] fiction does not pretend that all is well with race…Cautionary future tales are important articulations of our own expectations for life because they are often emotional reactions against the trends and events of society" (p. 117). Most *s*F stories may show futures where racial disparities among humans are no longer observable, but instead pass the mistreatment of people of color to an invading alien whose goal is dominion over the planet, which is not dissimilar from white-man's fear of the invading Other. Therefore, such *s*F plots may think they have "solved" humanity's racism-crisis, but have also created an Other that humans are racist towards. Lavender continues, "It could be that science fiction's frequent assumption of a color-blind future – whether an unintentional or deliberate privileging of whiteness – has blinded critics to matters of race" (p. 157). This is as if because all matters of human-racism have been solved, it is expected for there to be an Other to rally against. A *scientifically* literate analysis of *s*F can allow for such discussions about how racism is just as institutionalized in imagined futures as it is in reality.

When racism is absent in future stories, a *science* literate individual would ask, "Where did it go?", "How was it resolved?", etc. However, removing racism from the future can also be a deliberate attempt to discredit the real issues in racial injustices. In other words, avoiding racism in *s*F is a way for the author to acknowledge that racism is bad, should not exist in the future, but the specifics of how racism exists is not necessary to tell the desired story. According to Dubey (2011):

> The erasure of racial distinctions in science-fictional images of future societies might be
> indicative of an evasion of the race problems rather than a solution. Racial distinctions in

science fiction are often eclipsed by human-alien encounters that provoke the solidarity

of humanity in response to the threat of alien others. (p. 16)

The unfortunate reality of racism lies in its institutionalization throughout society. By simply

suggesting that in the future racism will not exist, discredits every individual and group that has

struggled with or protested against racial injustices. It is a "privileging of whiteness" to have the

audacity to pretend as if the importance of racism is so insignificant that it can just be imagined

away. This is not to say that imagining a non-racist future is bad; imagining a just society is ideal

as long as it includes a world setting where the trials and tribulations of social inequality are ever

present, and all citizens walk around with a metaphoric badge of honor demonstrating that they

had made it work. This is much different than simply erasing the struggle as if it was never

important enough to begin with.

In most *s*F stories, the hero that emerges is often a white male (or if not "white" in skin

color at least in mannerisms, and if not male than a female exerting very masculine traits). The

propaganda of such display of heroism leads the intended audience to be convinced that only

those resembling those traits can be heroic. Nama (2011) argues, "The image of a virtually

indestructible white man flying around the world in the name of 'truth, justice, and the American

way' easily opens up a Pandora's box of racial issues" (p. 33). Jackson and Moody-Freeman

(2011) posit:

Science Fiction films have generally reflected the same proclivities as has Science Fiction

literature. In most of the films, the heroes are white males, often in the character of an

explorer, scientists or gladiator type who prevails in spite of perceived human limitations

and frailty in the face of a powerful and technologically advanced alien intruder or

technological threat. (p. 5)

Seeing the white/hero character represents an opportune space for rich dialogue for *science* literacy development. This argument carries into the superhero genre as presented in both film and literature. The absence of non-white superheroes is apparent, the only exception being when a white superhero has a sidekick, which can be filled by a non-white individual since it has a smaller role in the greater narrative. Nama suggests, "The lack of recognition given to black superheroes as sci-fi objects is not all that surprising given that many black comic book images easily fall into the uncomplimentary category of racial caricature" (p. 35). Discussing this void of non-white superheroes opens the dialogue to include the non-*scientist* into a *s*F discussion, utilizing a *science* literacy he or she did not know they may have already had.

The topic of race in *science*, specifically how *Science* constructs race, is too important to be ignored or overlooked by the general population. Incorporating a medium such as *s*F can provide just enough entertainment value to interest the audience in a dialogue about how we view and experience racial disparities. Lavender (2011) argues, "It is essential to build a dialogue with existing theories of [science fiction], racial science, and popular culture in order to create new ideas about how to apply [science fiction] studies to race" (p. 24). These conversations can develop *science* literacy and also begin to engage individuals, especially students, into a critical debate about race. According to Lavender

> Acknowledging and dealing with race in [science fiction] may have a significant cultural effect for the twenty-first century because it can prepare us for the looming social changes that may descend upon us as America ceases to be dominated by the white majority…We will be in a strange territory with such alarming changes, and [science fiction] has already charted a few new paths through that territory. These paths present both opportunities and challenges for society to establish new values. (p. 25)

Visualizing the future and how race fits into it becomes a significant dialogue to engage students in, since it is they that will inhabit the future, wield opportunities, determine policy, and vote. If they have not had real, challenging debates about how society's racial tendencies can evolve both with and without action, then real change is further away than even imagination can take us.

Gender in *science* Fiction Curriculum

The situation of gender in *s*F is not dissimilar from race in *s*F. The perspective becomes clear if *s*F is analyzed with the same critical lens, using the foundation of how women are marginalized in society and connecting that institutionalized sexism with the images of females in *s*F. The common understanding, both in reality and *s*F, is "Men deserve to rule women because only the masculine command of science improves culture" (Roberts, 1993, p. 32). This statement can be adjusted to not speak directly about men and women, but between masculine and feminine. In Chapter 4 I argued that although women have played increasing roles in *scientific* (and *Scientific*) projects, the credibility of those projects is dependent on the defeminization of the researcher (i.e., masculine is objective as feminine is emotional). Through institutionalized sexism, past instances involving women in *science* are too often used as examples of failure simply because the researcher was feminine. Therefore, using *science* literacy, the conversation must look not to the past but to the imagined future where society's views of the feminine can be altered. Penley (1997) posits:

> If we accept that "space" remains one of the major sites of utopian thinking and that "going into space" is still one of the most important ways we represent our relation to science, technology, and the future, we need to examine the stories we tell ourselves about space and about women in space. (p. 22)

The stories of *s*F are rife with circumstances that use women as the enemy against heroic-masculine *Science*, and by analyzing those stories we can catch a glimpse of where we are potentially heading as a species.

Since women, and therefore feminine *science*, is regarded as such a threat to the dominating masculine *Science* women can find themselves portrayed as the enemies in the imagined futures of *s*F. Most of these stories are contrived by men who themselves see the feminine as threatening. Weaver (2004) argues it is "not uncommon for women to play antagonists' roles in the plot as they threatened not only men in their safe laboratories but also in the universe" (p. 34). The role of women though is not necessarily portrayed as some diabolical female *Scientist* with ill intentions. Rather the antagonist takes the shape of an alien species, led by a queen; the queen being the major antagonist. Roberts (1993) writes, "As in many later works of science fiction, it is the female alien's ability to reproduce that makes her so threatening to the male protagonist and patriarchal society" (p. 24). So long as the queen survives, the enemy multiplies and presents real danger for humanity. No matter how many invading alien soldiers fall, the queen (apparently) can reproduce new soldiers instantly. The fear of a woman's ability to reproduce is not irrational in *s*F, since such concerns are already evident in society. Talks about birth control, abortions, and government spending on Viagra are all examples of *Science*'s concern that women's ability to reproduce is more dangerous than any other factor that contributes to reproduction. Hence, in *s*F it is the duty of the hero to dispense of the queen and save humanity.

In some dystopian *s*F stories, the ability to reproduce does not make women villains, rather it becomes the women's enemy. Consider the web-streaming service Hulu's adaptation of Margaret Atwood's 1985 novel of the same name, *The Handmaid's Tale*. Popularized by Hulu's

series, the story takes place in a dystopian future where rampant pollution has caused global infertility. The structure of society is then shifted as the role of women is reduced to their ability to give birth. If able to bear children, these women are enslaved as handmaids to elite-class couples, where the husband can impregnate the handmaid through ritual intercourse (rape) because the wife is infertile. The patriarchal-dominated society is a common setting for females that find themselves in imagined futures. This is, of course, expected given how modern society is also predominantly patriarchal. Hence, incorporating feminist *sF* can challenge these images by empowering the women in them to rise against. Roberts (1993) argues:

> Feminist science fiction repeats what is implicit in the founding concepts of patriarchal society, the dichotomy between masculine and feminine that traditionally oppresses women but which feminist science fiction uses to empower itself. Feminist science fiction looks at the dualities of masculine and feminine, traditional science and feminist science, and shifts the terms of the pairing to privilege the marginal over what is usually central. And in the process it deconstructs the binarisms of patriarchy. (p. 90)

By understanding the patriarchy that is institutionalized in society, *s*F can be used to imagine feminist futures where women are not labeled by their femininity. Roberts continues, "Because science fiction allows writers to adapt ideas about progress to include women, the feminist utopia provides a blueprint for the future. In addition to encouraging readers to rethink traditional stereotypes" (p. 69). The main purpose for *science* literacy curriculum to have these dialogues about gender (and race) is to shift the paradigm of the stereotypes that run the injustices of society. However, simply incorporating *s*F into the *science* curriculum is not complete; there is no single place where such a curriculum can survive without the foundation to think critically and effectively question the information. Therefore, to build *science* literacy, to effectively use

*s*F as curriculum, learning institutions must be critical and democratic, and nourish the creativity and imagination to create these futures. Instead, these *institutions of the corporate state* diminish creativity, label imagination as "day-dreaming" or distracting, and are far from the critical education that society needs it to be.

Institutions of the Corporate State: The Death of Creativity

Most educator training courses I have taken have been led by professors who emphasize the teaching practice as it pertains to younger grade levels, specifically in elementary grades. Designing a mock lesson for these courses requires an entire day's worth of activities. I have listened to elementary teachers go on about the activities they had their students do: coloring, building, problem solving, inquiry-based learning, discovery. When it is my time to present as a high school teacher, my activities vary wildly from theirs: I have to lecture for 1-2 days, make students sit silently and do practice problems, then assess. Blades (2001) agrees with this approach:

> Spend some time in most secondary school "science" classrooms and typically you find students sitting in desks, facing forward, listening to a teacher lecture. These presentations draw together a collection of "facts" from the ponderous body of information produced by modern science; often these facts are given to students in considerably more detail than required by the curriculum guides as teachers use their university lecture notes to prepare class. (p. 71)

This has been the traditional experience of most students by the time they have reached my classroom. Sure, there are exceptions and some students may have had some opportunities to individualize their learning. But the further students get the less those opportunities exist. An example of this creativity diminishment can be experienced when assigning a high school

student a project/presentation. Students will ask if they can do projects the way they have been *taught* to do them through the years ("Is PowerPoint OK?"). The last thing the student wants to hear is the teacher saying, "be creative." At this point in students' development, they have lost even the ability to comprehend what "be creative" means. This is even more troubling within the *science* classrooms, where creativity, imagination, and innovation should be the main attributes needed to be successful. But public education stifles these characteristics as it enlists curriculums that suit the needs of industry and complacent citizenry, making public schools *Institutions of the corporate state* (*ICS*), and it is these curriculums that need to be challenged.

Curriculums inside *ICS* are the results of political leaders determining what is needed to compete in the world economy. Therefore, the death of creativity begins with the politicization of education. Pinar (2012) writes, "The consequences of this politicization of public education have been numerous, catastrophic, and continuing. The first has been to focus curriculum funding on [*Science*], mathematics, and technology, marginalizing programs in music and in the visual and other arts" (p. 106). By limiting access to music and art programs, the creative outlet for most students diminishes. This has the ripple effect of also telling students who are gifted in music and the arts that there is no future for them since their abilities will not help them through the content that has been deemed important for them. Robinson (2017) suggests the rise of industrialism is to blame for the current state of public education. In Robinson's view, *ICS* are designed to match the traditional factory: "schools were planned with special facilities, with boundaries that separated [students] from the outside world, set hours of operation and prescribed rules of conduct. They were designed on the principles of standardization and conformity" (p. 46). Immediately, students enter a space that disallows creative expression or imaginative thinking. Robinson continues, "[Students] moved through the system in age

groups…as if the most important thing that children have in common is their date of manufacture" (p. 46). The older students experience a learning day that is separated by ringing bells, not unlike bells heard in a factory to signal the start and end of the work day, lunch, or break times. In the end *ICS* produces students that are well trained to join the factory line without the need of a learning curve.

Because of its lack of creative outlets, students lose interest in the process of learning itself. Weaver (2010) posits, "Public schools have become only a shadow of learning. Schools proclaim that they will prepare the young for life in the world but the only thing they prepare students for is to take standardized tests" (p. 125). Once students have left the building, they are only a statistic in the school's all-important graduation rate. In my time in education, I cannot recall a time when my school bragged about where students ended up, only how many left the school by graduating from it. Therefore, students are pressured and molded into products that increase the reputation of the school, not by what students have gone on to accomplish but by how well they performed against other students at other institutions taking the same assessments. Shapiro (2008) quips, "The difference between those who are successful at school and those who are not is that the former forget what they learn after the test rather than before it!" (Chapter 1, "The Emptiness of Learning," para. 3). Learning becomes irrelevant as brute memorization becomes the desired skill for being successful in schools. However, after school ends graduates are greeted by an adult-world that depends on their skills, their literacy, and their ability to engage in democratic practices. Weaver (2004) writes, "After following a carefully controlled and manipulated curriculum, young adults leave schools wondering why the world does not fit the illusion their schools created. But instead of questioning the curriculum they wonder what's wrong with them" (pp. 27-28). *Science* education experiences a similar disconnect from the

classroom to the real world. This is similar to what Blades (2001) refers to in *Science* education as a "simulacra of science education", since *Science* classrooms have become focused on the standardized delivery of facts designed for students destined for *Scientific* careers and post-secondary work (p. 80) and have moved away from the creative inquisitiveness that *science* naturally is, and students naturally are. The further curriculums move away from creativity, the harder it is to develop *science* literacy, and the more dominant *ICS* becomes.

The learning environment is ruled by test-driven curriculums, which are the main culprits in the death of creativity. Students are only motivated to "learn" because of an arbitrary letter designation. Mistakes and failure have become stigmatized into being a one-and-done pathway towards life-long exclusion from a prosperity. Shapiro (2008) states, "Students learn in the competitive, test-driven, and grade-obsessed school environment that what counts has little to do with the pleasure of learning, or the intrinsic value of greater understanding" (Chapter 1, "Becoming Manipulative, Thinking Instrumentally," para. 2). To students, schools are nothing more than a stage in life that corresponds to their age; it is unavoidable and is only supposed to last for a set amount of time. Shapiro continues:

> The process of education feels more and more like a necessary evil to be endured and survived, one that must be dealt with in ways that call on the least expenditure of students' intellect of emotion, as long as it ensures successful passage to the next stage of their lives. (Chapter 2, "Crisis of Meaning," para. 1)

It is challenging to think of possible solutions to this travesty, perhaps because as a product of *ICS*, I lack the creative and imaginative capacities to do so. But perhaps that is where the solution lies, in refocusing education towards the creative capacities of those it is meant to appeal to. Doing so can at least produce graduates that are creative and imaginative enough to argue

against the policy makers that develop "solutions" to educational problems, which originally were the solutions those same individuals thought up for different problems (they also created).

Creativity and imagination are essential to the *science* literacy necessary for the issues present in the world. However, *ICS* do not allow for room in the curriculums to develop such skills. Instead of new challenges, new perspectives, and varying degrees of applications, students are expected to learn with muscle memory. Weaver (2010) argues, "Pure repetition irritates the mind…If not treated the mind disconnects itself from the body and if continued and irritated more eventually it contaminates the whole body as students avoid learning altogether" (p. 120). This returns to Shapiro's (2008) joke of who is successful at school. The creativity of students is rendered useless in a curriculum where memorization and repetition are all that is needed for success. Returning to *Science* curriculums, Blades (2001) argues, "After years of learning to regurgitate information…their vision and curiosity die, leaving only a lingering disgust that after so many years of learning science they really have learned little that is worthwhile" (p. 72). I see this every day in the physics classroom, where no matter how much I attempt to open the environment for the students to be creative, encourage mistakes (without grade penalties), and allow freedom to express themselves, students still respond with apathy and indifference, unless its relevant for the test. "The sad truth," according to Shapiro, "is that for most kids, schooling is a process that gradually closes down the spirit of questioning and intellectual curiosity…it is a process that also disinvites students from challenging and interrogating the supposed truths that are set before them" (Chapter 5, "Authentic Learning," para. 1). How, then, can we expect students to graduate into a society where the very ideals of democracy are not allowed to be developed beforehand?

In *ICS*, the removal of experience is also a smoking gun in the death of creativity. A *science* curriculum depends on the experiences of the learner, since their experiences shape their perspective of the world. This in turn leads to questions, curiosity, investigation, creativeness, imagination, and innovation. Blades (2001) posits, "Rather than being taught…to explore through experience children begin early a careful march toward a death of their desire to know" (p. 74). It is no wonder that *Science* has controlled the narrative of so many areas of culture if lived experiences are absent from *science* training. The absence of experience only increases the longer students remain in school (Blades, p. 74). Reflecting on my own experiences, I did not develop an interest in learning until my last two years of college. The first two years were much like high school: I needed to pass the required classes though most did not interest me, so all that I cared about was what I needed to do to pass. In the later years of college, I began to focus my studies on the things that interested me and once I realized I had the capacity to learn I wanted to continue learning. I was filled with regret that I did not take advantage of the learning opportunities that presented themselves throughout high school and early in college. However now, through my doctoral work, I have accepted the conclusion that my lack of interest in school was not entirely my fault, and the design of the curriculum I was subjected to is partially to blame. I left high school thinking the same as everyone else: It was a waste of time, but I finished and it's time for the next thing. This is why these issues facing education need creative thinkers, equipped with a *science* literacy to question the curriculums responsible for oppressing the individuality of students, stifling the creative and imaginative capacities of children, and making its products (graduates) incapable of recognizing the need to question and challenge the legitimacy of *ICS*.

Where is Critical Education?

The necessity to challenge circumstance begins with a critical education. Public schools fail at delivering such opportunities. Collins (2009) posits, "Schools operate by identifying truth, packaging it, and by hiring people to discipline kids to accept it" (p. 108). Rather than engaging students in dialogues and debates about social structures, or the purpose of their education, students are taught to follow a rigid set of rules with emphasis on the types of punishments incurred depending on the infraction. Teachers, then, are pawns in this system, directed to only maintain order and deliver facts and not to encourage any form of free-thinking. Collins continues, "Teachers are technicians who are 'trained' to implement someone else's ideas and theories. Teachers are not supposed to challenge the curriculum. Rather their job is to 'teach' it" (p. 96). The art of teaching has been in a death spiral for a long time, as evaluative measures and negative attention through the media has positioned teachers into a lesser-class of professional. In many debates about the struggles of teachers, many non-teachers tout the simplicity of the profession, how anyone can "babysit" a bunch of kids, and that teachers are paid more than they deserve – considering it is only nine months of work a year. The autonomy and expertise of the teacher has disappeared, which leaves students vulnerable to remnants of what was once a creative, sympathetic individual. The vessel that now instructs students is void of character and diminishes the dreams and aspirations of their students.

ICS are brilliantly designed. They exist within a much larger system of control that works in tandem like a well-oiled machine. The system benefits when the necessary peasant positions are occupied, and *ICS* have positioned themselves to produce the peasants that are willingly searching for those positions. Collins (2009) posits, "Public schools are largely designed to train students to fit into what already exists, not prepare them to imagine something different. Public

schools are not in a good position to create safe spaces for informed critical debate" (p. 92).

Incorporating informed critical debate develops skills, akin to *science* literacy, where the

structures in place – *ICS* and the "machine" – are no longer protected by their own design.

Shapiro (2008) adds, "Most schooling in the United States teaches young people little about

thinking critically about their world" (Chapter 5, "Mindless Learning, Thoughtless Lives," para.

2). Without thinking critically, students are susceptible to the dangers of manufactured

uncertainty, voluntary ignorance, blind obedience, and mindless consumption. Further, how are

students to be prepared for the injustices of the world waiting for them, be it racial, gender, or

otherwise? Shapiro continues:

> In all our talk about improving education, there is almost no concern with a critical
>
> education, and its responsibility to inculcating the values and attitudes that are essential to
>
> a vibrant and meaningful democratic culture. The detachment, ignorance, and cynicism
>
> that are so rampant among students in regard to what their education is about are sad
>
> testimony to this fact. (Chapter 5, "Educating for Democracy," para. 1).

Figuring out a way to get students to reconnect with the purpose of their education is paramount.

The more *ICS* are allowed to make that determination for them, the more they will disconnect

themselves from learning. As adults, not wanting to learn is a voluntary ignorance that breeds a

culture that is complacent towards injustices, environmental destruction, and seductive

consumerism.

A critical education builds *science* literacy, a skillset that emphasizes critique, analysis,

and questioning. Being restricted from questioning the curriculum, both as students and as

teachers, reflects the adult world, where policies and political agendas are believed to be

impervious to challenge. Collins (2009) argues:

> Surely, figuring out solutions to important social issues…requires more nuanced analysis than sound bites on talks shows or ideological formulas from the far right and far left. More importantly, the contentious practices that are associated with early-twentieth-century U.S. politics as usual mute the kind of critical thinking that is necessary for democracy itself. (p. 30)

The realm of public education represents the best, if not only, space where effective change can occur. If every teacher in America stands in front of 25 students each day (and in upper-grade levels it would be 25 kids per hour), then a critical-*science* literacy curriculum can reach an entire generation at once. When those individuals then enter the adult-world, they will be ready to engage with it. Collins adds, "Classrooms are places where people practice dialogues across differences in power generated by structures of race, class, gender, and sexuality, and in this sense, they are essential to practicing resistance against these structures of power" (pp. 101-102). Giving students opportunities to discuss the issues facing society gets them to understand the importance of questioning the structures that society is built on.

Engaging in a new curriculum is a necessary start. However, even though the classroom is the ideal place to get started, there first has to be a challenge to what is being forced into the classrooms. While it is important for students to discuss social issues, Collins (2009) posits, "Kids spend enormous amounts of time in the physical space of their schools, yet schools typically suppress this kind of open and honest dialogue" (p. 91). As *ICS*, public schools serve to place students into an expected role in society, one that supports the institutions of oppressive rule rather than oppose them. Collins writes, "Schools do many things in a society other than teach academic facts and skills…They control access to jobs, sort people into groups, attempt to

control what we think and say, attach privilege to some and not to others, and…perpetuate social inequalities" (p. 4). This is the curriculum that needs to be challenged. As schools teach facts and skills, there is a curriculum that forces the conversations to remain on the facts and skills and not engage in dialogue of critical issues, what Collins refers to as the "hidden curriculum". Thus, to challenge the hidden curriculum begins by revealing it. When conversations about the hidden curriculum become more accessible by an informed public, a demand for change can occur.

Why, then, do I feel *science* is pivotal in this unveiling of the hidden curriculum? Because *science* is a process that seeks to uncover truth, it is an epistemology that is not satisfied by spoon-fed answers but would rather search for answers itself. The *scientist* is capable of questioning and challenging what is hidden because he or she knows how to engage in inquiry. With an education that builds *science* literacy, every student can become the *scientist*. Whether they become a literary *scientist*, mathematical *scientist*, social *scientist*, or *Science scientist*, the desired effect to generate a population that knows how to critically think about information presented to them is the foundation of an effective democratic society. Rather than focus on nourishing the *scientist*, *ICS* trains *Scientists*: individuals who would rather profit from knowledge instead of growing from it. Weaver (2010) posits, "In the world of entrepreneurial science and 'academic capitalism' discoveries are made in order to convert knowledge into patents and students attend lectures in order to turn notebooks into paychecks" (p. 46). Students are not encouraged to think critically but are expected to become critical thinkers; students are expected to be problem solvers but are only tasked to solve problems with known answers. Shapiro (2008) argues:

> All of this effort and time may provide decent, or even exceptional, grades and test results. But we need to ask ourselves, what in the world does all the material students are

now required to "cover" have to do with our proudest and noblest vision of a citizenry

that knows how to reason, question, and think? (Chapter 1, "The Emptiness of Learning,"

para. 5)

For a moment, teachers and curriculum writers have to reimagine themselves as toddlers, so

incredibly curious about the world that asking "why" is a response to every answer received.

"Why are we teaching this way"; "Why are we standardizing education"; "Why are the tests the

only measure of success"; "Why can we not engage students in discussions about societal

issues"? These are all questions that curriculum developers have to start asking. The curricular-

scientist knows how to ask these questions. Training teachers to be *scientifically* literate gets

them to think about these questions. Overall, *science* and *science* literacy are necessary tools to

begin debates with relevant "why's". Dyson (2006) writes, "If science ceases to be a rebellion

against authority, then it does not deserve the talents of our brightest children" (p. 7). Further, not

only *science*, but if education and democratic engagement ceases to be a rebellion against

authority, then they too do not deserve the talents of our brightest citizens.

Democracy and Critical *science* Literacy for the Future

Because students are not engaged in effective conversations about issues facing society, it

is difficult to understand the expectation that they will be effective as a citizen of democracy.

Since education is so restrictive of these dialogues, students' understanding of democracy is

vastly different than what is desired. According to Collins (2009), "How Americans

conceptualize democracy itself shapes how we see ourselves in it, how we assess its current state

of being, and what changes, if any, we think should ensue" (p. 13). When students' views of

democracy are skewed in favor of a curriculum that decides what to say and how to think, then

American democracy becomes nothing more than a battle cry of pseudo-freedom. The *scientifically* illiterate citizen engages with the world as if being part of a "democracy" is a badge of honor and bestowed allowance to brag about it. However, Weaver (2010) argues:

> Democracy and the development of the mind are the latest casualties in the rise to dominance of global capitalism. Now public schools exist for three reasons; job training for future workers, docile test takers, and future consumers. Public schools have become an integral part of the local and global economy. (p. 6)

Therefore, as students leave *ICS* they are left to believe that democracy is a freedom towards dominance. Most historical curricula show American democracy as the epitome of government throughout the world, that because of democracy America is the authority over all other non-democratic nations. Students have equated America's democratic ideology with its imperialism of the world. Further, as long as students are trained to yell at non-democratic ideals their backs will be oblivious to their own subjugation to the power brokers of American dominance.

Students must be taught that democracy is not an option that is awarded to its citizens. Rather, democracy is the constant engagement of citizens in challenging the policies and politicians that attempt to declare what is right and wrong. Collins (2009) argues, "Democracy is a *process*, a way of building community and getting business done – it is typically something that is not bestowed upon us by people at the top, but rather something that bubbles up from below" (p. 12). But educating students to become more involved in the democratic process is not enough. The unfortunate reality is that because of the lack of a *scientifically* literate education, the general population is not informed enough to make conscious decisions for the betterment of the whole. Consider the burning of fossil fuels in consumer vehicles: consumers are going to want to drive their gas-guzzling SUV's regardless if they understand the effects it has on global

climate change. It then becomes the responsibility of the government to enact regulations on

vehicle manufacturers to limit the amount of emissions, which are then debated in the political

arena as an attempt of government overreach (usually argued by those who are financially

supported by Oil corporations or car manufacturers). The citizens, then, are put in a position to

have to choose which is the correct viewpoint, but remember, they also want to drive their

SUV's. This cycle of being uninformed, mislead, then having to choose a side is why American

democracy is not a democracy, but instead a pseudo-democracy where being able to vote is more

important than being informed well enough to engage in the debates. Collins posits, "We must

find a way to make democracy work" (p. 12), because democracy will not work without the

involvement of its citizens. Therefore, the population must be taught how to engage in

democracy, how to question, how to challenge, how to investigate and inquire, and how to draw

conclusions based on fact and not rhetoric. Society must become *scientifically* literate if it is to

establish the democracy it always thought it had.

Education is an important part of society. It is, as Robinson (2017) suggests, "One of

those topics that run deep with people, like religion, politics and money. It should. The quality of

education affects all of us" (p. 7). However, if an education system is built to recognize those

that succeed and fails to encourage those that do not, then how can such a system possess the

credibility for having the capability of preparing everyone for democratic citizenship? How can

building a *science* literacy be an accomplishable goal if it is already believed that only some can

successfully acquire it? Part of the answer is to get students to reconnect with the humanity of

education, the purpose of being educated in society. Reconnecting with the humanities is a

liberal arts approach to learning that emphasizes the accomplishments of humanity rather than its

grievances. Further, since humans occupy the same space as nature, it becomes necessary for

education to not only reconnect with humanity but also to the natural environment. Weaver (2010) argues, "A properly guided liberal arts education leads to an acceptance of the order of nature and proper place of humanity within nature" (p. 37). A democratic education that wishes to engage its citizens in society must also make those citizens aware of their effect on nature. As one of many species on one rock, it is hard to comprehend why a democratic education would be about anything else.

Since the goals of a democratic education are to build social engagement and reconnect with humanity and nature, the emphasis of schools' curricula need to deemphasize core subjects and revisit the importance of liberal arts, humanities, and the *science* literacy that interweaves with them all. Weaver (2010) posits:

> An aggressive humanities education within public schools and universities would simultaneously invite the sciences back into the fold as natural philosophy while encouraging non-science students to get involved in scientific matters in order to assure the [sciences] serve democratic purposes. (p. 39)

The liberal arts and humanities have the capability of reversing *Science* back into *science*. As *Science* innovates new technologies, it needs to be challenged in order to gain perspective on its overall effects on the world. If *Science* and *Scientists* are left to ponder whether or not they could, then something needs to be in place to ask them whether or not they should. Weaver continues, "If scientists are invited into a dialogue with the humanities new policies on how to best proceed with stem cell research, cloning, gene therapy, pharmaceutical drug research and other research agendas within the biosciences can emerge" (p. 39). By engaging *Scientists* with the liberal arts, humanities, and *science* literacy, the effective result can be to challenge the

capitalization of *science* and return it to its roots: an inquiry meant to serve the betterment of humanity and nature, not to exploit either of them.

Building *science* literacy, imploring a democratic education that reemphasizes the liberal arts and the humanities, are just small pieces in the grander narrative of education and the place of *science* within society. If society wants democracy it can no longer remain voluntarily ignorant, no longer allow for manufacturers of uncertainty to control information, or allow for the capitalization of *science* to invent the world in order to subjugate its people. If members of society want to engage in democracy, they must develop the *science* literacy skills necessary to do so. Society must invent the world, not expect it to be invented. We must be educated well enough to envision the world as we want it to be: fair, just, and centered on sustainable consciousness. We must also be educated to want to make change in the first place. Ask the students what they want humanity to be remembered for: its bombs or its music; its vicious treatment of others or its compassionate treatment of others; challenging ill-practiced authority or being complacent in it? Ask students to envision a future that is utopian, then ask what changes need to be made, what institutions need to be challenged, and above all, what are they going to do to invent that world.

EPILOGUE

"If I have seen further it is by standing on the shoulders of Giants." – Sir Isaac Newton

"So in the face of overwhelming odds I'm left with only one option: I'm gonna have to science the shit out of this" – Matt Damon as Mark Watney, *The Martian*

This journey has drastically changed everything I thought I knew about science. Initially I perceived science to be universal, transcending matters of racial and gender inequality, nationalism, and social class structures. For me science represented a unifying process which forced us to gaze beyond the things that separate us and focus on things that unite us. Science meant peace, equality, and prosperity. I was quick to dismiss others' arguments to the contrary, suggesting their positions were fueled by their inability to understand science. When assigned Nancy Cartwright's *The Dappled World* for a class, I remember naively thinking that Cartwright only wrote about the faults in scientific methods because she could not understand the process and therefore resorted to criticizing it. Then I was introduced to the works of Paul Feyerabend, Sandra Harding, Donna Haraway, among others and I came to the realization it was I who did not understand science. I began to see that I was a *Scientist*, hiding behind factoids and supposed objectivity, shielded in unique vocabulary and high level mathematics, all so I could feel as though I was elevated on some moral high-ground. If I know science then I cannot be racist, sexist, susceptible to manipulation, or defenseless against false information, right?

I believe now that I have transitioned to the *scientist*, looking for what is happening behind-the-scenes while information is being forced at me, as if the intensity and frequency somehow correlate to credibility. The most prominent transformation I have experienced has come in the shift from the education-*Scientist* to a *science*-educator. As the former I promoted my course-content as the single-most important part of my classroom. These *Scientific* facts were

infallible and too significant to be overlooked. Questions were limited to clarifying information or reexplaining difficult concepts. Relevance and cultural-significance related questions were not addressed. My students were required to complete their work on time, no exceptions. Students were expected to do the required homework, pass quizzes and tests, and accept the grade as it was calculated, no questions asked.

As a *science*-educator, I see things differently. More accurately, I empathetically approach my lessons. While the importance of my content as it pertains to an upcoming assessment cannot be ignored entirely, I now find myself more aware of the individuality of my students. I am more open to engage in discussions that gets my students to think critically and ask questions they may not have thought to ask. More often than I should admit, these questions and discussions extend beyond the curriculum limitations of my course content. While it would be understandable to describe these conversations as a waste of class time , I would counter by arguing that engaging the students in asking questions about topics important to them instills a hunger to understand more, no matter the subject or level of difficulty. I find that when I participate with students in dialogues about societal issues, I have engaged them in developing a *science* literacy that (re)learns how to question, investigate, and remain curious.

I am proud of the *scientist* I have become. By (re)learning to question, I have begun a never-ending process of peeling layer upon layer of misdirection, misinformation, pseudo-claims, manufactured uncertainty, and sleight-of-hand tactics used to control narratives and push agendas. (re)Learning to question is truth-to-power, an expectation of accountability, and is therefore necessary for a society infected by struggles for supremacy, authority, and idolization. By developing *science* literacy, perhaps students will (re)learn to question efficiently and effective enough to create the democracy America pretends to have. This is why I enjoy the

discussion with my students that gives them a voice in my classroom. I want to feel hope that the next wave of individuals entering the adult world are prepared to engage with it, shape its policies to benefit as many lives as possible, for as long as possible. I want to believe that while I am restricted by the *Institutions of the Corporate State*, my students are not and can be inspired to shake the foundations of the institutions that sustain oppression and inequality. As I probed deeper into how *Science* has manufactured the world, I started to understand why it is necessary to never stop questioning, remain curious, and always be aware of those who wish to control how we think rather than inspire us to think. As I found how *Science* has created conflict throughout the world, I began asking how to work towards a tomorrow that is improved form today. The more I learned about *Science*, the more I wanted to rebel against the structures that seek to exploit lives for someone else's gain. The more I understood *Science*, the more I became a *scientist*. By (re)learning to question, I have had to (re)think science so that I can become a better *science* educator for my students and for myself.

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