The Emerging Scientist:

Collectives of Influence in the Science Network of Nineteenth-Century Britain

by

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ABSTRACT:

At the beginning of the nineteenth century, there was no universal term to describe a person who practiced science. In 1833, the term "scientist" was proposed to recognize these individuals, but exactly who was represented by this term was still ambiguous. Supported by Bruno Latour's theory of networks and hybridity, *The Emerging Scientist* takes a historical approach to analyze the different collectives of individuals who influenced the cultural perception of science and therefore aided in defining the role of the emerging scientist during the nineteenth century.

Each chapter focuses on a collective in the science network that influenced the development of the scientist across the changing scientific landscape of the nineteenth century. Through a study of William Small and Herbert Spencer, the first chapter investigates the informal clubs that prove to be highly influential due, in part, to the freedom individuals gain by being outside of formal institutions. Through an investigation of the lives and works of professional astronomer, Caroline Herschel, and physicist and mathematician, James Clerk Maxwell, chapter two analyzes the collective of professional practitioners of science to unveil the way in which scientific advancement actually occurred. Chapter three argues for the role of women in democratizing science and expanding the pool from which future scientists would come through a close analysis of Jane Marcet and Agnes Clerke, members of the collective of female popularizers of science. The final chapter examines how the collective of fictional depictions of science and the scientist ultimately are part of the cultural perception of the scientist through a close reading of Shelley's *Alastor; or, the Spirit of Solitude* and Wilde's *The Picture of Dorian Gray.* Ultimately, *The Emerging Scientist* aims to recreate the way science is

studied in order to generate a more comprehensive understanding of the influences on developing science and the scientist during the nineteenth century.

For my husband, Adam, your constant love, support, and understanding made it possible to complete this daunting task.

~

For my parents, you instilled in me a passion for learning and knowledge that led to this point. Thank you for reading to me every night as a child and teaching me that the path to everything can be found in a book.

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INTRODUCTION

Overview and Framework

A study focused on Victorian science is no longer, or really, never was, sufficient to understand the advancement of science and the development of the scientist in the nineteenth century. Traditionally, the Romantic period is recognized for its emphasis on the imagination and creativity, and therefore, not on its contributions to the development of science. Douglas Bush encompasses this traditional Romantic ideal when he writes, "one main impulse in Romanticism is the conscious and subconscious revolt against the Newtonian universe and the spirit of science" (Goellnicht 3). Yet, in fact, Romantic writers and practitioners of science are inherently linked to the writers and scientists of the Victorian period; and together, they help understand the development of science, which, during this period, created a space for individuals outside of the traditional role of natural philosophers as practitioners of science became more professionalized. These individuals would come to be called scientists by the late nineteenth century. The purpose of this investigation is to better establish the role of both the Romantic and Victorian periods in the emerging identity and construction of the scientist.

Today's culture seems to assume that a great divide between science and literature has always existed and that science and the humanities are not linked. Given this errant view, literature and the humanities have no role in the development of new technologies or new strains of thought in science. However, such assumptions about science and literature are short sighted and miss a history of interconnectedness where men and women who practiced science and the men and women who commented on society and politics in writing were one in the same. This shortsightedness is what makes this study so necessary. We have, as a collective society, constructed a hard divide, one which never existed at the time, between Romanticism and science, especially between Romantic literature and science. This study aims to show how vital multiple collectives of differing individuals with different purposes were in contributing to the development and advancement of science and the construction of the scientist; and more importantly perhaps, how vital the Romantic and Victorian period were in developing a cultural perception of the scientist that continues to influence our understandings today.

One can see this process of constructing a divide between science and the humanities unfolding in the Victorian period through the debates regarding education between Matthew Arnold and Thomas Huxley. The discursive divide between the humanities and science starts in the late nineteenth century and is crystallized in the twentieth. In 1959, C.P. Snow attempted to dissuade society from continuing down a road that divided and isolated science and the humanities into two separate fields. Snow, a trained scientist and novelist, gave a lecture in 1959, *The Two Cultures and The Scientific Revolution,* which was later published in book form. Through observations of his own interactions in the differing fields, Snow claimed that

> the intellectual life of the whole of western society is increasingly being split into two polar groups…Literary intellectuals at one pole—at the other scientists…Between the two a gulf of incomprehension—sometimes (particularly among the young) hostility and dislike, but most of all lack of understanding. (3-5)

Snow argues that this has replaced interactions common during the earlier phase of cultural formation. Snow's commentary is problematic in that although he may highlight the negative outcomes associated with a separation, he actually helps solidify such a divide by calling science and literature "two cultures". Even with Snow's attempts, however problematic, to show why it is important to engage the so-called opposition, or other culture, over 50 years later, society is still dominated by the need to separate science and literature rather than unite them.

However, the real issue for this study is not society's current views of science and literature, but rather the need to articulate more accurate historical view of these cultural processes of production. We have failed to understand the actual development of science by not recognizing the constant interconnection that existed between practitioners of science and discovery and writers and literary scholars. Acknowledging the continuous interconnections between science and literature during the nineteenth century allows for an investigation into the development of the scientist that takes into consideration more than just the people practicing science at the time. Focusing on a more inclusive nineteenth century study of science, one which analyzes literature produced by practitioners of science during the period, organizations devoted to science and scientists, popularizers of science, meaning those writing about science for a popular audience, and fictional depictions of science and the scientist, provides a more thorough, cohesive, and historically grounded understanding of the cultural perception of the scientist *in situ*.

There has been an influx of scholarship on science in Romantic studies over the past two decades. Much of the initial work being done on Romantic science was structured as a history of science, focused on the men (and women) practicing science during the Romantic period and how their lives and work influenced the development of the field. For example, Graham Burnett chronicles the change in the way that Europeans, specifically the British, viewed the rest of the world in *Masters of All They Surveyed.* Burnett uses the literal practice of exploration, which ultimately leads to geography and cartography, as the central theme to his history of the growing British Empire. Andrew Cunningham and Nicholas Jardine edited a volume of essays, *Romanticism and the Sciences*, which asked its contributors to focus on the "Romantic views concerning the relationship between the self and nature" in their individual histories of the science of the time (2). Similar to Burnett, this text provides a history of science as it developed during the Romantic period and was influenced by Romantic philosophies.

Scholarly texts such as Alan Bewell's *Romanticism and Colonial Disease* and Tim Fulford, Debbie Lee and Peter Kitson's *Literature, Science and Exploration in the Romantic Era* take a step further than just a history of science and work to incorporate Romantic literature into the discussion of Romantic science. Similarly, the popular work by Richard Holmes, *Age of Wonder*, tells the story of a few scientists during the Romantic era with a connection to the literary scholars of the time, yet it fails to offer any real insight on how the relationships between the practitioners of science and the writers affected their lives and work. Additional scholarship on Romantic science tends to highlight the influence of scientific discovery on literary texts or how literary texts respond to scientific developments. An example of this type of scholarship is Richard Sha's article "Volta's Battery, Animal Electricity, and *Frankenstein*" where he "situates

Frankenstein within the Volta/Galvani debate about the existence of animal electricity" (1). Sha argues that Shelley invoked a specific science in order to comment on a cultural debate, which aligns him with other similar science scholarship in Romantic studies.

Similar to Romantic studies but of greater volume, Victorian studies has a plethora of scholarship on science. The Victorian period is a hotbed of scientific development, and developments during this period modernize science into fields and disciplines as we understand it today. As with the Romantic period, much of the scholarship in the Victorian period focuses on the history of science and those practicing science during the period. For example, Christopher Herbert's *Victorian Relativity* analyzes the role of numerous scientists during the Victorian period and their roles in developing early theories of relativity. Ursula De Young's *A Vision of Modern Science* focuses on one particular scientist during the Victorian period, John Tyndall, and his impact on science and the cultural perception of science as a way to "examine a pivotal moment in the history of science" (DeYoung). Focused on Victorian science and its role in Victorian culture, Bernard Lightman's *Victorian Popularizers of Science* analyzes the individuals who undertook the important cultural work of popularizing and publicizing science and scientific progress in society. The men and women analyzed in Lightman's text played a significant role in the development of science during the Victorian period. However, these texts, although making significant contributions to Victorian science studies, only look at one aspect of science during the period: the practitioners of science or those who popularize its outcomes. Gillian Beer's *Darwin's Plots* connects the scientific theories of Darwin with George Eliot and her literary texts in the nineteenth century. Such critical work has succeeded in establishing the importance of the literature and science, or the practitioners and popularizers of science in Victorian studies, but such analyses fail to provide a more historically grounded understanding of science in the nineteenth century.

As important as these studies in the field of Romantic and Victorian studies and science are, they still leave a gap for further study, which this project aims to bridge by approaching nineteenth century studies of science from a new perspective. Through a study that focuses on both the Romantic and Victorian influences on science and the perception of the scientist, this study aims to highlight a more cohesive conception of nineteenth century science and in turn, will acknowledge fully the role of the Romantic period in its development as well as recognize the varied and many different influences that contributed to the development of the scientist.

The theoretical framework and background for this study is primarily a historical and interdisciplinary approach. However, the work of Bruno Latour and his anthropological studies of science provide an important foundation for the basis of this study. Latour's 1991 study, *We Have Never Been Modern*[1], attempts to rethink the "modern" forced separation of science/technology and nature. Latour argues that moderns have "cut the Gordian knot with a well-honed sword. The shaft is broken: on the left, they have put knowledge of things; on the right, power and human politics" (Latour 3). In this study, Latour discusses the idea of hybrid networks and collectives in his

[1] Originally published as *Nous n'avons jamais été modernes: Essais d'anthropologie symmétrique*

rethinking of the matter of nature and technology assumed in the "Modern Constitution." Latour defines hybridity as being a unity between matters of nature (politics of men) and matters of technology (scientific knowledge). Hybrids are not subjected to the need to purify and define objects as being just nature or just technology—they are by definition connected—hybrid (Latour). Ultimately, Latour argues that there is no real justification or method to separate nature and technology because of their inherent hybrid or dual nature. One cannot separate the influence that nature has on technology and vice versa; thus, there really is only hybridity—understanding objects through networks and collectives that are made up of both nature and technology.

In Latour's 2005 text, *Reassembling the Social,* he reasserts claims made in *We Have Never Been Modern* and expounds on ideas presented earlier throughout his work. Latour argues that a "network is a concept, not a thing out there. It is a tool to help describe something" (131). For this study, using "network" to describe science in the nineteenth century becomes a useful tool to show how science was not one clearly defined and stable thing, it was a compilation of many things. Science itself is a Latourian hybrid comprised of a network of actors, or influencers. Michel Foucault's work on knowledge and power and the archaeology of discourse precedes the work of Latour discussed here, but one can assume was influential in Latour's work, as it also helps explain the basis for the theoretical foundation for this study. *The Foucault Reader* (1984) provides a series of interviews where Foucault was given the opportunity to explain some of his more complex theories. In one interview focused on ideas of truth and power, in a response to a question, Foucault answers, "It's not a matter of locating everything on one level, that of the event, but of realizing that there is actually a whole order of levels of different types of events, differing in amplitude, chronological breadth, and the capacity to produce effects" (56). Here, Foucault is asserting that one needs to let go of preconceived ideas about what is influential or not, and recognize that many factors contribute outside of one's initial scope. He continues by claiming that "The problem is at once to distinguish among the events, to differentiate the networks and levels to which they belong, and to reconstitute the lines along which they are connected and engender one another" (Foucault 56). The goal that Foucault prescribes here is underlying the goals of this project. To come to a more comprehensive understanding of the emerging scientist, and what that meant in the nineteenth century, we need to try and distinguish the different networks or levels that contributed and influenced the development of the scientist. Through providing links and showing the connected nature of these different influencers, one will arrive at a more thorough understanding not only of the emergence of the scientist, but the way in which science functioned throughout the nineteenth century: as a vast network.

Thomas Hankins and Robert Silverman apply Latour and Foucault's arguments of interconnectedness of networks and hybridity to the discussion of Romanticism and science in *Instruments and the Imagination* arguing,

> We historians of science need to study romanticism because it is the most important alternative in the west to the "scientific" mode of thought engendered by the Scientific Revolution. We have learned at considerable cost that these alternative modes of thought are seldom exclusive and that we make mistakes when we do exclude them from what we might wish to regard as "real" science. The natural philosophy of the Scientific Revolution may have had to "overcome" the alternative of Aristotle and the occult sciences, but it did so only by incorporating large parts of those

> philosophies that it "overcame." Likewise natural science "overcame" romanticism but did not remain unaffected by it. (Hankins and Silverman 86-87)

As Hankins and Silverman point out, one cannot remove Romanticism from understanding the development of science even if it is not contributing in the way in which we might expect contributions of science to be made today. Romantic science was not professionalized; amateurs and wealthy gentlemen who had interest in nature and understanding the world around them practiced much of the scientific experimentation during the Romantic period[2]. Yet even given the lack of professionalization and schooling, the study of nature that was occurring both in the scientific experimentation, artistic expression and the literary writing of the Romantic period was deeply influential on the development of science and the scientist as we understand them today.

To best understand the complex relationship of science and culture now termed the scientific revolution, the Romantic era must not be avoided in route to the late nineteenth and early twentieth century to attempt to understand the progression of the field of science. In fact, the work done during the Romantic period provides the crucial link for understanding a cohesive progression of the development of the scientist. One did not go to sleep a natural philosopher in 1800 and awake as a scientist in 1890. Science did not just skip over the Romantic period, and to claim that the work being done during

[2] Dwight Anderson claims that although there were some semi-professional members of the scientific community involved in the Society during the late 18th and early 19th century such as medical doctors, academics, and lecturers, the "overall character of the Royal Society strongly reflected the genteel and amateur scientific community at large" -- *Scientific Discourse in Sociohistorical Context: Philosophical Transactions of the Royal Society of London 1675-1795* (Mahwah: Taylor Francis Group), 27.

that period had no influence on the advancements of science appears illogical in light of the clear evidence of scientific advancement during the late eighteenth and early nineteenth centuries. Latour and Foucault's theories highlight and substantiate the argument made here: one cannot remove the influence of a variety of forms of literature connected to science when attempting to define and understand what constituted the scientist during the nineteenth century.

Necessary to this discussion is a definition of what exactly the project aims to understand. The goal is not to discover and show what constituted the identity of different scientists during the century but rather to uncover and understand the construction of the cultural "scientist" in the force field of cultural production. Understanding the scientist involves the characteristics attributed to the idea of the scientist, and therefore the nature of public perception becomes very important to the overall project. One exceptional way to understand public perception is to look at the literature[3], as it is both influenced by and reacts to the science and practitioners at the time. In "Thick Description: Towards an Imperative Theory of Culture", Clifford Geertz describes the term "thick description" as a way to conduct an ethnographic or anthropological study that goes beyond just the surface level in order to provide a more comprehensive and accurate understanding of the culture studied (6-7). In alignment with Geertz' theory, this project does not strive to replicate past critical work to understand the inner-workings of the lives of scientists. More precisely, the goal is to use both people in the science network and the literature

[3] Literature, for the purposes of this study, reflects all forms of writings produced by individuals in this period. This will include scientific publications, journals, letters, essays, and novels.

they produce to understand what surrounds the construction of the scientist in the mid to late nineteenth century, providing context through "thick description" (Geertz).

The term "scientist" was first mentioned in writing in *The Quarterly Review* in 1833, but it was not until 1840 that the term was defined (OED). Phillip Davis in *The Victorians* explains how "William Whewell coined the specialist term "Scientist" in 1840, in his *Philosophy of Inductive Sciences* (57). Whewell stated, "we need very much a name to describe a cultivator of science in general. I should incline to call him a Scientist" (Whewell). With the growth of the popularity and importance of science, there became a significant need to have a term to group the people who experimented and devoted their time to discovering the workings of nature no matter the specific discipline. The choice to use "scientist" in this project is not a failure to recognize that the term is first used in 1833 by William Whewell, but rather a purposeful choice to highlight the connection of the characteristics shown in this analysis with what becomes recognized as the scientist. The terms "natural philosopher", "*savant",* and "man of science" were used during the Romantic period and early Victorian period to represent men working in the pursuit of science. However, they are not solely functional for the purposes of this analysis, since this analysis highlights the pivotal change from "natural philosopher" associated with early Romantic pursuits of science to the subsequent emergence of the "scientist" in the late nineteenth and early twentieth century. The call for a scientist—a new term—occurred not as a result of developments of Victorian science even if the definition was solidified during that period. What is most interesting is that this call for a designating term occurred in 1833, defined in 1840, which means that it is a result of developments in the field of science during the Romantic period. Ultimately, Victorian science and its numerous developments, such as distinguished fields of study, the separation of science from the church, among numerous other changes and advancements, are facilitated by what the men and women working with science in the Romantic period produced. This, then, highlights the need in Romantic and Victorian science studies for a project that does not isolate the individual fields, but as this project does, acknowledges the interconnection between the two periods that is essential to understanding the development of the scientist across both periods. Therefore, at times throughout this study, Romantic figures might be referred to as scientists, as they most closely fit with the term scientist rather than the traditional terms used to represent such people participating in the sciences. Thus, the best term to use when referring to these individuals is "scientist" with recognition of the seemingly anachronistic usage implied by the term itself.

Background

The nineteenth century was a revolutionary period for science in British society. One main goal of those involved in science in the Victorian period was to establish a place of authority in society that consisted of scientists—the experts in science. Bernard Lightman explains how men of science were "players in the contest for cultural authority" (*Victorian Popularizers* 9). This authoritative body could aid in decisions made aimed at progress in all societal interests. The goal was to have a secular authority that forced the church to relinquish its role of ultimate decision maker of what is best for the people. Samuel Taylor Coleridge helps us to understand this need for change in the social hierarchy. Coleridge was not only a famed Romantic poet but also a philosopher and man of science whose influence spanned the entire nineteenth century. For Romantics, he was a poet philosopher who brought the power of nature and the imagination to life. For Victorians, he was a philosopher and lecturer discussing the key philosophical quandaries surrounding the advancement of science and the progress of society.

Furthermore, Coleridge plays a significant role in this study because it is his call for a clerisy that demands a change in the social hierarchy of academics and scholars, thus heralding in a conceptual space where science could flourish and develop a level of authority that demanded a special designation for those practicing in the field of science. In 1829, Coleridge philosophizes about a need to elevate the learned class into clerisies in *On the Constitution of the Church and State*, which helps facilitate the growth and authority given to science and thus helps open up the necessity for a scientist—a term designating scholars of science belonging to the clerisy.

In an 1817 letter to Lord Liverpool, Coleridge is beginning to expatiate his ideas for a new philosophy for the country, his nation of Britain, to follow. As Ben Knights describes in *The Idea of the Clerisy in the Nineteenth Century,* "the National health required the acceptance of what Coleridge was beginning to call the "dynamic philosophy" (38). As Knights continues, the "mechanical philosophy which is should replace was, he argued, inimical to social life because it located life not in the whole but in parts” (38). Knights’s aim with this part of the text is to set up an argument that the philosophy set out in Coleridge’s final full publication in 1829 was actually part of a philosophy he had been developing throughout his life and career. Yet others, such as Halmi, Magnuson, and Modiano, claim evidence to the start of this philosophy even earlier in Coleridge’s career in 1795. In Coleridge’s *A Moral and Political Lecture*, he considers the role of the “small but glorious band, whom we may truly distinguish by the name of thinking and disinterested Patriots” who constantly push the bounds of knowledge “as they advance the scene still opens upon them and they press right onward” (245). The editors of this piece claim that “embedded here is [Coleridge’s] idea of the “clerisy,” which was to develop later (Halmi et al 245). Ultimately, whether one adheres to Knights or to Halmi, Magnuson, and Modiano is not important. Critical to the discussion is the evidence put forth that Coleridge’s philosophy that is expounded in detail in *On The Constitution of Church and State* is one that had been influenced and dwelled on for many years.

This final work, Coleridge’s new philosophy, is juxtaposed against the philosophy of the enlightenment that separated and isolated and instead is “a return to harmony, to a recognition of the essential interconnectedness of things” (Knights 41). Coleridge recognized the dangers associated with a separation of powers and authority and calls for a new authoritative body, a class of the learned to help usher in progress and preserve civilization. Coleridge, with much of his work, adapted previous ideas or philosophies to fit the cultural need of his time. One easily sees the similarities in Coleridge’s call for the clerisy to Plato’s call for the Philosopher-King in *The Republic.* Plato calls for the

Philosopher-King because "the many have no knowledge of true being, and have no clear patterns in their minds of justice, beauty, truth, and…philosophers have such patterns" (75). Plato desires rulers that are dedicated to virtue and truth and they are unwavered by the petty nature of the life of man (75). They are not ruling for personal gain, but as symbols of knowledge and truth.

Coleridge, influenced by the Philosopher-King of Plato, creates his own version in his call for the establishment of the third estate and authority of the clerisy. In *On the Constitution of the Church and State,* Coleridge calls for a "third great venerable estate of the land" necessary for progress and civilization (45). The aristocracy and landowners form the first estate, and the second estate is comprised of "the merchants, the manufacturers, free artisans and the distributive class" (45). This new third estate, as Coleridge calls for, would be comprised of "the learned of all denominations, the professors of all those arts and sciences, the possession and application of which constitute the civilization of a country" (xv). Coleridge's proposed third estate is aimed at organizing individuals who are experts in their fields and recognizing them for their roles and contributions to society beyond just classifying them as learned. These individuals are not just interested in their fields of study, but hold a serious role for Coleridge and due to their expertise, are owed a significant and recognized place in society. This designation is attached to an obligation to share such knowledge with the rest of society as it is necessary for the progress of civilization, according to Coleridge (45).

Coleridge calls this estate the National Church and the members of the National Church, the experts of the arts and sciences, comprise the National Clerisy. The role of the National Church and Clerisy was "to secure and improve that civilization, without which the nation could be neither permanent nor progressive" (47). Coleridge assigns the educated scholars of individual fields of study a significant place in the cultural makeup of British society. Ultimately, Coleridge argues that without this recognized class, the civilization for British progress is hindered, if not halted. Further, beyond just recognizing these individuals, Coleridge proposes a specifically recognized place to organize and establish "learned of all denominations, the sages and professors of the law and jurisprudence, of medicine and physiology, of music, of military and civil architecture, of the physical sciences, with the mathematical as the common organ of the preceding; in short, all the so called liberal arts and sciences" (49). By recognizing and assigning a specific place in society for the clerisy, Coleridge is also then assigning a particular authority to these learned individuals that was not present before. An authoritative voice reigning over society and assigned to the scholars is quite progressive for the time. At a point where the Church held most authority in instructing the people, Coleridge appropriates some control from the Church and assigns authority to the learned. Tasking the clerisy with the progress of civilization is a significant weight to bear; however, what is essential to understand is that Coleridge trusts in the knowledge and capabilities of this class of individuals to function as instructors of the people. Just as members of the Church were needed in every town to promote and facilitate the teachings of the church, the clerisy was needed for the transference of knowledge of all disciplines in order to facilitate progress. Real progress was held in the hands of the clerisy who were the pillars of their fields. This knowledge would need to be distributed to the people. This is a significant assignment for the clerisy and one that is imbued with authority by its design to embed knowledge widely in the public sphere.

Important to note is that Coleridge is not undermining the role of the Church in his philosophy and call for the clerisy. Rather, as he specifically states, “religion may be an indispensable ally, but is not the essential constitutive end, of that national institute” (48). The clerisy, the instructors of the National Church, remain dedicated to continuing to develop knowledge in the sciences and arts; they are not part of religion, although they are not anti-religious or excluded from religion. Coleridge argues that these endeavors may lead one to religion; it is an ally, but not the necessary end nor goal of the clerisy and the proffering of knowledge to society, in order to advance progress. Through this definition, Coleridge hopes to raise the learned class to one that has an authoritative voice, while still cautiously and purposely not excluding the Church. By remaining in a relationship with religion, Coleridge avoids alienating much of his audience and also sets up the possibility for an easier acceptance of his call for the clerisy. At the time Coleridge published in 1830, religion was still central to Coleridge’s life as it was to many who undertake scientific pursuits; however, Coleridge allows for the separation of science and religion, of education and religion by acknowledging religion as an ally, not a necessity. Removing religion as a necessity lays the groundwork for the more distinct separation between science and religion that comes in the future (i.e. the latter part of the nineteenth century).

Through the lens of Latour, this project will primarily take on a historical analytical perspective as it juxtaposes Romantic and Victorian texts in each chapter, yet the juxtapositions also partake of the inherent dynamism of Coleridge's views. Each chapter will be dedicated to highlighting a different group of scientific influencers, or as Coleridge defines, clerisies, ranging from practitioners of science and famed members of scientific societies to the depictions of science and the scientist in fiction. For this study, I will refer to these scientific influencers, or clerisies as collectives. Using Latour as a theoretical foundation provides the scaffolding for a new analytical approach for examining science in the nineteenth century. Approaching the science collectives as part of a science network eliminates the "scales or criteria by means of which the different nodes in this network can be valued against one another" (Mitchell 39). In other words, this project, by using collectives in a science network, evaluates each collective equally for its contribution to science and the forging of scientists in the nineteenth century rather than pitting them against each other and arguing for one's importance over the other.

Following this methodology, all science collectives are equally part of the scientific network in the nineteenth century through which the figure of the scientist was constructed. Because science was not singular, isolated, or defined through much of the century, the more productive view of science as a network offers a better framework wherein all contributors are recognized as part of the whole. Furthermore, Latour justifies the inclusion of all collectives working within science in the century, including fiction, given that "the notion of 'applying something' from one realm to another depends upon the premise of distinct realms, each of which has its own proper elements and borders" (Mitchell 34). No aspect of science was yet to be fully defined or separated from one another throughout much of the period under examination, so it is not a valid claim to say literatures merely adapted or applied scientific thought in their writing. Rather, the fiction and numerous other forms of literature (including science) are equally part of the science network that, together, constructed the figure of the scientist in the nineteenth century. The scientist is a Latourian hybrid as it is a result of the multiple collectives in the science network and their individual contributions to science and the way in which they help to illuminate how science functions as part of society as a whole.

The idea or definition of a scientist is one that was malleable and constantly changing throughout this period. The influence on the public understanding of the scientist came from multiple directions and differing groups of individuals. Understanding the role of the different collectives in the period, as they are related to science, provides the framework for analyzing the characteristics of the scientist. Just evaluating one group or a few individuals—a trend in previous scholarship—underestimates the size of the public sphere of scientific influencers during the century, denying the notion of a science network through which one can recognize all contributions made in forming the cultural perception of the scientist. While acknowledging the difficulty in doing justice to such a comprehensive list of people, this project categorizes the scientific influencers into groups, or collectives, with similar roles. Identifying key collectives that contributed to the public perception of science and thus, the scientist, allows for a more comprehensive discussion of science in the period. This comprehensive approach also allows for the inclusion of individuals that are often left out when discussing science in the nineteenth century, such as women writers. Focused on a single collective, with examples from both the Romantic and Victorian period, chapters include a general discussion of the role of the collective in science and the public understanding of science. Additionally, a closer analysis of specific Romantic and Victorian figures allows for the similarities and differences of the times to be emphasized while still providing evidence for how each influenced the public's framework for understanding the character of the scientist. A conscious effort is made in each chapter to select individuals for close analysis that are not the most famous or most popular. Part of the goal of this project is to bring to light the collectives of influencers who are often left out of the focus in the history of science during the period. This goal finds its way into each chapter in the figures discussed.

Organization

The first chapter is dedicated to a discussion of the role of organizations in the advancement of science and the scientist. Rather than focusing on the formal societies such as the Royal Society or the British Association for the Advancement of Science, this chapter focuses on the informal clubs that prove to be highly influential due, in part, to the freedom individuals gain by being outside of formal institutions. The Romantic section of this chapter looks closely at the famed Lunar Society. A close analysis is made of William Small, a physician and professor by trade was critical to many of the advancements in science that came out of its members. Small, a founding member, helps to substantiate the significant expanse of the contribution of the Lunar Society and its members to science. The Victorian section of this chapter analyzes, in a similar way, the role of the Victorian dinner club, the X Club, and how this club and its members influenced much of the focus of science in the Victorian period, but more importantly, how the X Club was responsible for popularizing science and bringing science to a place of authority within society. Herbert Spencer, a popularizer, writer, and sociologist, will be closely analyzed in this chapter. Spencer, an original member of the X Club, played a quieter, yet still important, role in the X Club, the development of applications of evolutionary theory to social structures, and the greater scientific establishment in the Victorian period.

Chapter two focuses on the collective of professional scientists during the century. Specifically, this chapter will focus on key individuals who spent their professional lives in the pursuit of science as practitioners. Although the majority of individuals with the opportunity to pursue science during the Romantic period were men, there were numerous women working in the sciences who made significant contributions. One such scientific woman was Caroline Herschel and her life and work will be analyzed closely in this chapter. Herschel was the first female to discover a comet, but more importantly, she was the first professionally paid female astronomer. Her role as a scientist is key in understanding Romantic science. When one thinks of scientists in the Victorian period, Charles Darwin is often the first to come to mind. For the Victorian section of this chapter, though, a close analysis of James Clerk Maxwell, mathematician and physicist, will depict the role of a professional scientist in the period. Maxwell's contributions to his scientific fields continue to influence many today, and his valuation of the imagination is key in depicting how scientific advancement was actually achieved in

Victorian Britain. These first two chapters present subjects that are more traditional in a study of science. The members of the societies discussed were practicing members of the scientific community in addition to their involvement in their respective societies and clubs. The second chapter, as many studies before have focused, looks directly at scientists--those who devoted their professional lives to the advancement of science.

The first two chapters focus on collectives that without question belong in the science network, while the final two chapters move away from traditional science studies to explore collectives that bring the public and cultural sphere into the science network adding uniquely to perspectives of science and the emerging scientist during the nineteenth century. Chapter three evaluates the collective of female writers who popularized science for the public—the non-scientific elite. Often left out of nineteenth century discussions of science for their presumed lack of original contributions to science, popularizers play a significant and decisively underestimated role in the development of science in the period as they are responsible for expanding the purview of science to go beyond the elite university educated to involve a greater community including the working class and women. This chapter provides a close reading of Romantic writer Jane Marcet and Victorian writer Agnes Clerke whose writings span the full century and provide a thought-provoking narrative of the democratization of science throughout the century.

Lastly, the final chapter in this project is dedicated to a collective of fictional depictions of science and the scientist. Looking at the role of fictional literature helps to illuminate a way that many in society were exposed to science and the idea of a professional scientist. A discussion of nineteenth century science in fiction would be incomplete without a mention of Mary Shelley's *Frankenstein* and H.G. Wells' *The Island of Dr. Moreau*; however, following with the trend of the previous chapters and the project as a whole, the close analyses provided will focus in more detail on texts not typically associated with science fiction for the unique way they bring questions of scientific themes and the scientist to the public. A close reading of Percy Shelley's *Alastor; or, The Spirit of Solitude* introduces the way in which the pursuits of the scientist and science are present in Romantic poetry. While in turn, for the Victorian period, a close reading of Oscar Wilde's *The Picture of Dorian Gray* shows how the novel is about more than just decadence as it presents a Victorian scientist's experiment on the human as the central focus of the novel. Fiction depicts society and culture and is the venue where much social critique can surface and infiltrate the minds of the public. And thus, the fictional depictions of science and the scientist make up a key collective of influence in the science network of nineteenth-century Britain.

The growing availability of printed material and the growing public who could consume it was directly connected with the public's growing interest in the sciences in the nineteenth century. As Noah Heringman explains, "the rapid expansion of print culture beginning in the later eighteenth century fueled the circulation of writings famously obsessed with nature, from Romantic poems and scenic tours to theories of the picturesque or the Deluge to the persistent and polymathic genres of natural history" (1). The interest and access that the public had to materials dealing with science help to explain the need to include more collectives in this discussion of the influencers on the scientist and science in the nineteenth century. Only investigating papers circulated by the Royal Society does not begin to cover the scope of material the public consumed during the period. Thus the chapters on female popularizers of science and fictional literary depictions of science and the scientist begin to make more sense next to discussions of practitioners and scientific societies in the larger attempt to understand science and the scientist in the nineteenth century.

This project may also look like one devoted to the history of science—the authority I have then to undertake such a task as a literary scholar may be questioned. However, in *Languages of Nature,* Ludmilla Jordanova, a cultural historian, argues,

> History of science can learn much from the methods of literary criticism, particularly in textual analysis. Treating scientific writings as literary texts involves, for example, asking questions about genre, about the relationship between reader and writer, about the use of linguistic devices such as metaphor, simile, and personification, about what is *not* being said. (20)

Much of this project hinges on the writing of the individuals in each collective, and thus members of the scientific network, in order to recognize their influence and contributing role in defining science and the scientist in the nineteenth century.

This study is not only valuable for scholars of science and literature in the nineteenth century, but the work it does to unpack and better explicate the function of the science network present during the century, which was essentially influential in the development of the scientist, contributes to current discussions of science and the scientist. In discussing the art-network, Robert Mitchell claims, "Past art-nodes can, as a consequence always be revived […] From this perspective, then, to return to Romantic-era experimental art is not to catalogue or describe the dead past but rather to create resonance among nodes by articulating the importance of experiment for the Art-network as a whole" (42). This theory of networks is easily applied to the science network discussed in this study. Considering nodes, or for this study, collectives, that were influential and significant to the science network in the 1800s is not solely to "describe the dead past" but notably, such consideration can be used to ground discussions of the science network and the scientist today (Mitchell 42). All nineteenth century collectives discussed in this project still hold a position as part of the science network. And thus, understanding the science network in the nineteenth century is still vitally important to understanding the science network today.

Coleridge's call for the third estate, the National Church and Clerisy, emphasizes the cultural and societal need for a title or a clearer designation and authority provided for individuals working in different academic professions. Even though this may not have been the goal or aim of the clerisy, when considered in regards to science, this need for a clearer designation coincides in time as the titles "man of science" and "natural philosopher" fail to be sufficient designations for those practicing science. Ten years before Whewell calls for a term to designate the people cultivating the sciences, Coleridge sets in motion the need to designate and distinguish members of society focused on expanding knowledge and understanding of the world. Coleridge, essentially, simulates this need for identifying titles by first organizing the scholars and learned professionals into the clerisy.

This project, like Coleridge's philosophy and Latour's emphasis on networks and hybridity, is a return to, or possibly more accurately, a call towards a new way of analyzing science and literature in the nineteenth century, one that focuses on and celebrates the interconnectedness of people, of groups, of collectives that is essential to understanding science and the scientist in the nineteenth century. As Coleridge once described, “The Clerisy of a nation, that is, its learned men, whether poets or philosophers, or scholars, are these points of relative rest. There could be no order, no harmony of the whole without them” (Qtd 759). This study applies the same philosophy of the whole to the societies, clubs, practitioners, popularizers, and fictionalizers working with science in the nineteenth century as they are highlighted in the individual chapters of this project. There is no harmony, no real understanding of science and ultimately, no real understanding of the scientist without consideration of them all.

ONE

The Collective of Informal Scientific Societies in Nineteenth Century Britain: The Lunar Society of Birmingham and the X Club

By the middle of the eighteenth century, literacy rates were skyrocketing in Britain and this produced an entirely new audience of readers. This new readership created a growing interest and demand for publications on science and the arts. The desire for science publications was both formal and practical and so it created a demand for both the traditional high language of the man of science as well as more scientific texts for the popular audience. As scientific texts were produced for the reading public, more and more people found an interest in science and reading was a way to pursue their own scientific leanings and inclinations. As more people developed interests in the sciences, demand also grew for opportunities and venues through which one could continue to exercise and develop scientific curiosity.

Scientific societies and organizations were a way to bring together people with similar interests in the sciences to create new discourse communities. “At the beginning of the eighteenth century there were only two formal scientific societies in Britain, both in London, and these were no longer adequate” (Schofield *The Lunar* 11). The Royal Society established in the Restoration remained in operation, yet due to organizational issues within the charter, it was dominated by non-scientific fellows and in the eighteenth century and showed little interest in the physical sciences. The other scientific society was The Royal College of Physicians, but they would only accept graduates of Oxford and Cambridge as fellows, which alienated the thriving medical graduates coming out of schools in Scotland as well as from established medical schools throughout the continent (Schofield *The Lunar* 12). This lack of established organizations at the start of the century led to an incredible influx in societies throughout the next two hundred years. Armytage writes about the influx of societies and publications and therefore of the expanding interest and prominence of science when he argues that "technology had found its clerisy in the academies—220 of them by 1790" (Qtd in Musson 58). The onslaught of scientific interest and the need for organizations led to numerous informal and more casual societies; however, the need for formal societies still existed, and the men of science at the time quickly adapted. An important role that the informal clubs and more formal professional societies played was that they "would build networks not just of intellectual exchange but personal sympathy, [often in the more formal case] under the steady leadership of 'masters in science'" (Ballon 226). By the end of the nineteenth century, there was a formal society for almost every scientific discipline one could imagine beyond the more casual and informal clubs and societies that abounded. The Royal Society and The Royal College of Physicians were still at the forefront of the formal scientific societies, but one could also find The British Association for the Advancement of Science, The Linnean Society, The Geological Society, The Chemical Society, The London Mathematical Society, The Royal Institution, and The Society of Civil Engineers to name just a few that grew to popularity during the late eighteenth and nineteenth centuries.

Therefore, the Lunar Society and the X Club were not unique in their formation as informal scientific clubs. Starting in the eighteenth century, there was an inundation of the desire for "men of similar tastes and interests to meet colleagues and friends socially...the informal club became the accepted social context for the exchange of new information and ideas, literary, political and scientific (MacLeod 305). Yet, Lightman argues, science became more common and significant to the social during the Victorian period. Hence, the dominance of the X Club is predicated on the earlier tendency to network with colleagues:

> The sciences...assumed tremendous significance in the second half of the nineteenth century as every theory, and every new discovery, seemed to contain huge implications for all facets of human life. Interpreting, and arguing over, the social, political, and religious meaning of scientific ideas became the focus of intellectual activity. (*Victorian Popularizers* Lightman 4)

Clubs were popping up everywhere to accommodate a number of different focuses and interests in the sciences and beyond. As scholar Jenny Uglow light-heartedly claims, "in the eighteenth century clubs are everywhere: clubs for singing, clubs for drinking, clubs for farting; clubs of poets and pudding-makers and politicians" (*The Lunar* xiii). The uniqueness, then, of the Lunar Society and the X Club is not found in their mere existence, as that has been proven to be commonplace, but rather through the specific men who gathered together at these clubs who were anything but ordinary and expected. The men drawn together in the informal scientific clubs of the Lunar Society and X Club were some of the most influential men of science during the long nineteenth century, and it is effectively because of their participation in these coteries that people today still know their names and find them worthy of discussion. The Lunar Society and the X Club stood out among the trend of social gatherings in their shaping of science in the nineteenth century.

The Lunar Society of Birmingham

Birmingham, England was a center during the industrial revolution of the late eighteenth century. The boom of industry was closely entwined with the growth of technology and innovation, heightening efficiency and creating an unheard of level of productivity. The potential for industry attracted a diverse group of people to the city. Innovation was key to the success of the city, and enlightenment thinking solidified the ideals of constant inquiry and the pursuit of knowledge. William Hutton described the unique nature of the people of Birmingham in his *History* of the city. Although he writes in 1741, his description of the city and its people presents a clear depiction of the life that would produce the Lunar Society: "They possessed a vivacity I had never beheld; I had been among dreamers, but now I saw men awake; Their very step along the street showed alacrity; Every man seemed to know and prosecute his own affairs; The town was large, and full of inhabitants and those inhabitants full of industry" (63). Birmingham became ground zero for enlightenment thinkers and innovators, and it was because of this that the Lunar Society was born. Friendships ultimately facilitated the initiation of the society as it evolved from discussions among peers with similar interests. The society got its name from the meetings that occurred each month on the Monday nearest the full moon. The meeting time selected had nothing to do with the astronomical pursuits or passions but rather out of practicality, since the light of the moon helped illuminate the journey home for the men at the conclusion of the meeting. The meeting would commence with dinner around two in the afternoon and close around eight in the evening (Priestley). Typically, the meetings would be held at the SoHo House of Matthew Boulton, one of its founding members.

The primary pursuit of the Lunar Society was to discuss science, innovation, technology, and production; yet the men who made up the society had numerous positions and occupied various places on the social ladder, which meant that discussions often included the arts and philosophy. Jenny Uglow contends “the strength of the group was...evident: diverse expertise created a broad knowledge base, helping them to solve problems and explore different avenues” (“Lunar Society” 1). Discussing science and the arts together in one meeting was common during the period because science and the arts were still connected. Without the professionalization and institutionalization of science, one could pursue both science and poetry simultaneously. One of the founding and more influential members of the Lunar Society, Erasmus Darwin, embodied this mindset to the core. He was a doctor by trade, one of the most popular poets of the late eighteenth century, and wrote an early theory of evolution among other scientific pursuits. Uglow writing about the membership of the Lunar Society, says “their powerhouse of invention is not made up of aristocrats or statement or scholars but of provincial manufacturers, professional men and gifted amateurs” (*The Lunar* xiv). United in a love for science, the Lunar Society grew out of conversations between friends and colleagues who had similar passions and interests in the sciences, as well as other strata of cultural production.

Debate was central, but hostility was alleviated through their devotion to science, knowledge, and inquiry, rather than religion and politics. Joseph Priestley wrote that "we had nothing to do with the *religious* or *political* principles of each other, we were united by a common love of *science*, which we thought sufficient to bring together persons of all distinctions" (195). A more democratic view of scientific inquiry held by the Lunar Society allowed for more fruitful and less divisive discussions between members. Membership was decided based on ability to contribute to the conversations at hand and an interest in similar pursuits, not the aristocratic level or size of landholding. Essentially, this is the reason that the Lunar Society was ultimately so influential and successful when it comes to scientific innovation. Although the Lunar Society was an amateur club not funded or sanctioned by some academy or royal grant, the level of work produced by these men led to at least 10 members becoming fellows of the Royal Society, including some of the most influential scientists of the time. Thus, there is no question of the influence of the Lunar Society on science at the close of the eighteenth and across the nineteenth century.

Typically, the Lunar Society is said to have operated from around 1765 to 1800. Scholar Robert Schofield argues that the start to the Lunar Society, what he calls the Lunar Circle, was earlier in the 1750s with the establishment of correspondence between Matthew Boulton (1728-1809) and Erasmus Darwin (1839-1914). Matthew Boulton was a Birmingham native born to a bucklemaker. He was educated until 14 at a local school at which time he left to join his father's business. He eventually became a partner in the business and took over the management of the workshop. He had an eye for business and invention and was a quick learner. Lunar Society member and partner in business, James Watt describes Boulton's abilities observing: "His conception of the nature of any invention was quick & he was not less quick in perceiving the uses to which it might be applied & the profits which might accrue from it" (Qtd in Schofield *The Lunar* 18). Watt's description of Boulton emphasizes his ability to be hands on and see the possibility of recent inventions or processes. This ability, praised by Watt, is what really brought the two together—Boulton learned of Watt's ideas for restructuring the function of the steam engine and Boulton saw the potential applications at his SoHo Manufactory. These ideas ultimately led to funding and a long lasting and fruitful partnership between the two men.

Erasmus Darwin, a key figure in the Lunar Society, first moved to Birmingham in 1756 at the age of 25. Based on correspondence, it is assumed that Darwin met Boulton soon after moving to Birmingham. The two became friends quickly as they both shared an interest in science. Darwin was trained in science and similar in age to Boulton, which meant their similar interests led to a quick and lasting friendship. Darwin was interested in science from his early days having attended the Hunter anatomical lectures in London, and then he continued his education studying medicine in Edinburgh and Cambridge (Schofield *The Lunar* 19). His scientific interests extended beyond the medical. Darwin kept journals throughout his lifetime where he would record his ideas and scientific pursuits. The topics of some of the entries range from medical discoveries and advancements to redesigning the carriage and a speaking machine, to discussions of chemistry, the mechanical nature of steam engines, water pumps, and canal locks, studies in botany and geology and creating an early theory of evolution (McNeil 1). Darwin was a true Romantic scientist. In addition to his scientific pursuits, Darwin connected his new ideas and more far fetched theories with poetry, producing multiple works that were highly popular. Noah Heringman explains how

> Erasmus Darwin has insisted...on the importance of obsolete for fanciful theories even in the rigorous precincts of natural philosophy: "[E]xtravagant theories...in those parts of philosophy where our knowledge is yet imperfect are not without their use; as they encourage execution of laborious experiments, or the investigation of ingenious deductions, to confirm or refute them." (9)

Heringman's description helps to provide background for Darwin's numerous works including far-fetched or fanciful ideas, even though his experiments ultimately led to many resourceful scientific discoveries. Scientifically, he would publish six papers in *Philosophical Transactions* on a range of scientific topics, the first of which focused on electricity and the properties of air. In 1761, he was elected as a Fellow to the Royal Society, the first of the members of the Lunar Society to do so (McNeil 1). Darwin's contributions to science during the period were vast and much resulted from friendships started in Birmingham that led to the formation of the Lunar Society. And it was in this society that Darwin was able to rely on his friends and colleagues for advice, help, and an exchange of ideas that nurtured scientific pursuit and discovery in a way that only an informal society could. The halls of the Royal Society were exclusive and elite, and although welcome to them, the dinner table in SoHo house would prove a more productive ground for innovation. Darwin, along with his close friend Boulton, would bring together like-minded men interested in scientific inquiry from all over Birmingham and surrounding areas.

William Small, who will be discussed in detail later in this chapter, was first introduced to Boulton and Darwin in 1765 upon his arrival to Birmingham and it is said that it was his “natural diplomacy [that] welded the group together” (Uglow “Lunar Society” 2). This group, beyond Boulton, Darwin, and Small consistently had about 10 members. Because of the little material written about the Lunar Society in letters and journals during the time, it is of some debate who was formerly a member versus one who just occasionally attended meetings. However, given the documents that do exist, one can confidently claim that James Watt (1769-1848) was a member. Watt, a chemist and civil engineer, is known most notably for his advancements in the steam engine, but he also made numerous discoveries in the refinement of metals. Additional members include James Keir (1735-1820), a chemist who engineered a formula for soap using alkali and produced it in his factory in Birmingham; also, he created the first and largest factory for soap in the world (Smith “Keir” 1). John Whitehurst (1713-1788), a geologist and instrument maker shared a passion with William Small in clock making, but he received his election into the Royal Society for his geological publication in 1778, *An Inquiry into the Original State and Formation of the Earth* (Vaughan). Thomas Day (1748-1789) is known mostly for his philosophical views, but was an active member in the society and often lent his financial support when necessary to fellow members (Rowland).

Additional members included Richard Lovell Edgeworth (1744-1817), a writer and engineer who developed a prototype for laying tracks; he was also very interested in theories of education and wrote much on the topic. Edgeworth’s friend Joseph Banks nominated him for election to the Royal Society (Colvin). Joseph Priestley (1733-1804), a chemist and natural philosopher is remembered most often for isolating oxygen, but he also published work on electricity among numerous other scientific endeavors (Schofield "Membership"). Dr. William Withering (1741-1799), a physician, botanist, and chemist moved to Birmingham to fill the position of doctor left by William Small's death at the request of Erasmus Darwin (Darwin 75-1). He was quite interested in scientific pursuits and quickly also filled the void in the Lunar Society left by Small. Josiah Wedgwood (1730-1799), a master potter who invented the pyrometer, a form of thermometer that would measure the heat in the kiln and allowed for a more perfected and efficient method of firing pottery (Reilly). The last two members were John Baskerville (1706-1775), a printer who created new printing types in addition to innovating the printing press creating more accuracy in printing (Mosley); and finally, Samuel Galton (1753-1832), a natural historian who published papers on light and prismatic colors while also composing and publishing a scientific children's book *An Introduction to Ornithology* (Smith "Galton"). All of these men, through historical evidence, were regular and active members in the Lunar Society (Schofield "Membership" 128, Priestley 195).

There were numerous other men who either attended the meetings upon invitation as they were passing through or visiting Birmingham or who attended meetings occasionally, but were not as active in continued correspondence, like the men listed. Sir Joseph Banks, a botanist and President of the Royal Society, Sir William Herschel, an astronomer and fellow of the Royal Society, Jean Andre de Luc, a Swiss geologist, Dr. Daniel Solander, a Swedish physician and librarian of the British Library, Dr. Pieter

Camper, a Dutch naturalist and anatomist represent many of the scientists invited to participate in Lunar Society meetings while traveling through Birmingham (Priestley 196). Additionally, famed painter, Joseph Wright of Derby corresponded regularly with the Lunar Society men. Fara argues that "as an associate of the Lunar Society, he was well versed in modern chemistry" and in addition to painting the portraits of many of the members of the Lunar Society, Fara claims that two of his paintings, *A Philosopher Giving that Lecture on the Orrery…* and *The Alchymist, in Search of the Philosopher's Stone…* are reflective of the Lunar Society and the scientific pursuits of its members ("Lunar Philosophies" 1-2). The esteem of the regular members attracted the most prominent scientists and philosophers of the time to join in for meetings when close by. Beyond the casual drop in, two notable members of the Society and contributors to scientific advancement during the century, James Watt and Joseph Priestley moved to Birmingham on the suggestions of members of the Society in order to be part of the innovative community offered.

The collective of men that claimed membership in this society consisted of the most important industrial and scientific minds during the time. Money writes in his study on Birmingham that the Lunar Society was, "the most remarkable of the elite groups of provincial intelligentsia which played a crucial part in the application of science to the problems of technological improvement and social change during the early industrial revolution" (10). Of great significance to the success and impact of the Lunar Society is how they recognized the more democratic nature of knowledge and science and therefore did not limit their pursuits to the great halls of the Royal Society. These men were able to come together without malice or personal motivations for success in the formal societies. The success of the Lunar Society is in part because it existed outside the establishment where future glories could be decided. Each individual member of the Lunar Society had his personal motivations and pursuits, yet they could come together and share their new ideas and engage in questioning and debate without the serious weight of the walls of the Royal Society closing in around them.

These men popularized science in a way that forever changed the makeup of Britain and the future of science. Uglow argues that it is the informality of the society and the diverse makeup of its members that causes such vast influences on the advancement of science and industry; "The members of the Lunar Society were brilliant representatives of the informal scientific web that cut across class, blending the inherited skills of craftsmen with the theoretical advances of scholars, a key factor in British manufacturing's leap ahead of the rest of Europe" ("Lunar Society" 1). Almost all members of the Lunar Society were part of the Royal Society, but the true knowledge exchange came from the Lunar Society and many were granted election into the Royal Society as Fellows as a result of the work that was a product of Lunar friendships and debate.

The discourse community created through membership in the Lunar Society was an incubator for technological advancement. These men formed an important collective in the science network during the time. Their contributions to the field were unique and significant. Specifically, their democratic nature leads to a depiction of the scientist that the public could relate to and appreciate. One of the most prominent members, Matthew

Boulton, was the son of a modest manufacturer, lacked an education beyond the age of 14 and made his way in the world through his entrepreneurial spirit and industrial savvy (Uglow "Lunar Society" 2). This allows for the idea that anyone, not just the wealthy and established, can pursue science. A scientist then, loosely defined through the help of the men of the Lunar Society, is a person who pursues scientific inquiry and innovation without the necessity of the proper education or relation. If the scientist holds the knowledge necessary to pursue the progress and advancement of his scientific inquiry, then he fulfills the necessary requirements of a scientist.

William Small, Founding Member of The Lunar Society

William Small is not the name that one would typically pick out for notable science figures in the Romantic era nor is he even the most notable member of the Lunar Society. Typically, as evidenced by their vast publications and prominent roles in scientific society, Erasmus Darwin or Matthew Boulton might seem the smart choice for influential man part of a scientific society in the set period. However, even without the publications and notoriety, one man, more than any other, is given the reference of being the reason that the Lunar Society ever really came together and established regular meeting times and memberships. That important and key scientific influencer is William Small. Although Small may not personally be responsible for any major scientific inventions or publications, his role and influence in the realm of science during the late 18th century is unmatchable.

William Small's early life and influences laid the groundwork for his future as an enlightened polymath. He was born in 1734 in Scotland and was awarded his MA in 1755 from Marischal College in Aberdeen, Scotland (Lane). While at Marischal, Small was exposed to new progressive styles of teaching and subjects, including studying under William Duncan who was a professor of natural philosophy. Through the exposure to studies in science, medicine and natural philosophy, "Small could be described as a son of the Scottish Enlightenment--a young man with a constantly enquiring mind" (Hull 102). Upon completion of his degree, Small applied for a teaching post in the colonies at the College of William and Mary. In 1758, Small began his post at the College of William and Mary and revolutionized the way subjects were taught by using the Socratic method of question and answer, creating the modern lecture format. He encouraged questions and presented demonstrations after the lecture to provide additional information to his students (Craig). Small's innovative classroom and lectures brought aspects of the Scottish Enlightenment to the Americas and inspired students that would become highly powerful and productive change-makers in the colonies. Hull explains, "John Page, three times Governor of Virginia...paid tribute to Small's teaching, which he said had inspired a lifelong interest in natural philosophy and mathematics" (103). More notable than John Page is one of Small's most promising pupils, Thomas Jefferson.

Thomas Jefferson studied at the College of William and Mary from 1760-1762 while Small was well into his appointment as Professor. Small was more than just a teacher to Thomas Jefferson, he was an influential friend and mentor. In a letter to L. H. Girardin in January of 1815, Jefferson further emphasizes the significance of Small in his life and on his future endeavors when he writes, "Dr. Small was...to me as a father. To his enlightened & affectionate guidance of my studies while at College I am indebted for everything...he first introduced into both schools rational & elevated courses of study, and from an extraordinary conjunction of eloquence & logic was enabled to communicate them to the students with great effect" (Qtd in Craig). The praise made of Small in this letter is significant in that Jefferson not only focuses on the influence that Small had on his own life, although high, but emphasizes the role Small had of innovating the educational system at the college. By instituting changes in the teaching system at William and Mary, Small was able to influence and encourage more students to pursue a higher level of inquiry in numerous new subjects. Small's teaching method not only revolutionized the structure at William and Mary, but the changes gradually spread and were adapted by colleges throughout America (Hull 103).

Small's influence on Jefferson goes beyond mention just in letters; Jefferson writes of his relationship with Small in his autobiography in 1821. He says,

> It was my great good fortune, and what probably fixed the destinies of my life that Dr. Wm. Small of Scotland was then professor of Mathematics, a man profound in most of the useful branches of science, with a happy talent of communication correct and gentlemanly manners, & with a enlarged & liberal mind. He, most happily for me, became soon attached to me & made me his daily companion when not engaged in the school; and from his conversation I got my first views of the expansion of science & of the system of things in which we are placed. Fortunately the philosophical chair become vacant soon after my arrival at college, and he was appointed to fill it per interim: and he was the first who ever gave in that college regular lectures in Ethics, Rhetoric & Belles lettres. (Jefferson 4)

Jefferson's praise of Small and his influence on him is significant and speaks to Small's ability to encourage constant learning and inquiry. Such encouragement is what produced the intellectual acuity in Jefferson that led to such a notable future. Precisely, Jefferson claims that it was Small who "fixed the destinies" of his life. Small's role in Jefferson's life may have been lost amongst the accomplishments of Jefferson, founding father of the United States of America, yet it is clear how influential Small was in creating the Jefferson that would lead a new nation. Small's apparent ease with conversation and his ability to communicate combined with his affectionate disposition is the foundation for how Small, talented and learned in many areas, became such an influential mentor and facilitative figure for so many. Small is said to have had many friends while at William and Mary, of particular closeness was George Wythe who he introduced to Jefferson and from whom Jefferson secured patronage. Additionally, historians claim that it was in 1763 in Virginia that Small was first introduced to and befriended Benjamin Franklin when Franklin was awarded an honorary degree from William and Mary (Hull 103).

Even with his surrounding of friends and intellectuals, Small appears to have had a falling out with the Board of Visitors at William and Mary and in part due to this was not made President of the College. Whether it was the dissention with the administration, the lack of advancement and promotion, or something else entirely, it was after this in 1764 that Small returned to England on a trip with 450 pounds and a commission from the Governor of Virginia to acquire scientific apparatus for the benefit of William and Mary (Ganter 506). Once back in England, Small decided to forgo a return trip to Virginia and leave his post at William and Mary altogether. He "dispatched the instruments, which included barometers, microscopes, an achromatic telescope, prisms, mirrors, and 'an instrument to trey the force of falling bodies.' This collection was recognized as the best of its kind in America until long after the revolution" (Hull 103). After Small sent the instruments home, he spent sometime in London surrounding himself with members of the Royal Society and participating in lectures on natural philosophy for medical students. In London, Small was re-acquainted with Benjamin Franklin and accompanied him to a meeting of the Royal Society (Schofield 24).

Although Small left Jefferson behind in Virginia, their friendship continued until Small's death. Most letters between the two were destroyed in a fire, but Jefferson's final letter to Small, which arrived after his death, speaks to the secure and important friendship that existed between the two intellectuals. On May 7, 1775 Jefferson writes to Small in detail about the start of fighting between the "king's troops" and his "brethren of Boston" and the ongoing dissent of the colonies with England ("From Thomas Jefferson"). However, it is through this discussion of politics and dissention that Jefferson establishes how important his friendship with Small was to him. Jefferson ends the letter saying, "I shall still hope that amidst public dissension, private friendship may be preserved inviolate, and among the warmest you can merit" ("From Thomas Jefferson"). The start of the American Revolution would not be enough to separate the founding father from his mentor. Even throughout fiery political turmoil and animosity, Jefferson valued Small and the influence he had on his life.

After Small's brief time in London, he returned to Marischal College in Scotland and received his MD degree in 1765. Upon completion of this degree, his friendship with Franklin provided him an introduction to Matthew Boulton in Birmingham where he was looking for a medical post. Franklin took the notion of introducing Small to Boulton seriously as he describes in the introductory letter that Small carried, "I would not take this Freedom, if I was not sure it would be agreeable to you; and that you will thank me for adding to the Number of those who from their knowledge of you must respect you, one who is both an ingenious philosopher & a most worthy honest man" (Franklin Qtd in Schofield *The Lunar* 35). This description of Small by Franklin not only mirrors that of how Jefferson always described the man, but it also laid the foundation for the formation of the Lunar Society.

Small's first introduction to Boulton, through Franklin, started the formation of friendships that led to one of the most productive scientific societies in the Romantic period. Boulton owned the SoHo Works and was a prominent industrialist and experimenter in Birmingham. Boulton and Small quickly became friends; Uglow describes how "[w]ith his easy, dry manner, Small quickly became Boulton's confidant, doctor, and unofficial secretary" (*The Lunar* 83). Small's extensive and wide-ranging knowledge of varied fields and disciplines within science, philosophy, and the humanities, combined with his good nature made him the perfect friend to have. Robert Schofield writes that "Boulton did very little, particularly in scientific matters, without Small's advice" (35). Particularly interesting about Small and Boulton's initial friendship is that it was with Small, not his future partner James Watt, that Boulton first experimented with steam engines (Jones 117). Small is said to have "urged [Boulton] to draw up a report on his steam-technology experiments in 1773" (Jones 119). There is no evidence that Boulton ever created the report, as it appears much of his innovations failed to make it into manuals or essays. Regardless, this shows how Boulton consulted Small in business dealings and in his new innovations. This emphasizes the strong role that Small played in Boulton's life and his scientific endeavors as well as the confidence and trust that Boulton held in Small.

After Small's arrival, Boulton quickly introduces him to the men of influence in Birmingham, which included Erasmus Darwin. Darwin, Boulton, and Small instantly became the closest of friends who regularly exchanged communication three-ways. Although Small's main interests were in scientific pursuits such as metallurgy, chemistry, mechanics, and clockwork, he continued to make medicine his profession. Regardless, his knowledge and interests in the field became valuable to the pursuits of Boulton and Darwin. Often, the three would consult each other on ideas, plans, and business pursuits.

In a letter dated 12 December 1765, Darwin writes to Boulton of his interest in receiving feedback from him as well as Dr. Small,

> ...to hear your final Opinion, and Dr Small's on the important Question, whether Evaporation is as[at] the Surface of boiling Water, or not? -- or if it be as[at] the Surface of the Vessel, exposed to the Fire, which I rather suspect...And I wish yourself and our ingenious Friend Dr Small will communicate to me your joint Opinion on this Head… I desire you and Dr Small will take this Infection, as you have given me the Infection of Steam-Enginry: for it is well worthy your attention, who are Friends of Mankind, and of the ingenious Arts. (Darwin, King-Hele)

This letter was written only seven short months after Small first moves to Birmingham and is introduced to Boulton. The extent that Darwin is anxious for his response and opinion on his experimental interests shows the respect that Darwin holds for Small. More so than just valuing Small's opinion, Darwin is anxious that Small too finds as much interest in the subject as he has. Darwin, also a doctor, did not just leave his friendship and consultations with Small to his scientific pursuits, but they often exchanged questions about medical cases that were causing them problems. For example, in a letter from June of 1769, Darwin consults Boulton and requests that he speak to Dr Small to confirm the presence of a disease (69-4). Small had referred a case to Darwin that dealt with Boulton's daughter, which had previously left him perplexed (King-Hele 102). The three men were more than just friends. They were collaborators, confidants, and business partners. Because of their close connection and intersecting interests, Small, Boulton, and Darwin are often referred to as the first and founding members of the Lunar Society. Important to note, however, is how Small's influence goes beyond consulting on medical questions or sharing ideas about scientific questions.

The interest that arose between Darwin, Boulton, and Small regarding the steam engine is not surprising given Boulton's professional interests. Boulton is most notable for his collaboration with James Watt and the production of the steam engine. However, surprising is that it was first William Small who arranged the meeting between James Watt and Matthew Boulton. Watt was interested in Boulton's SoHo Works and while in Birmingham met and quickly formed a friendship with Small (Hull 104). While Boulton was away, Small and Erasmus Darwin showed Watt around the SoHo Works factory and invited him to join their scientific society. Only later, on a subsequent visit to Birmingham was Watt finally introduced to Boulton by Small and this meeting was the seed of the eventual partnership between Watt and Boulton forming the firm of Boulton & Watt (Ritchie-Calder 139). Watt lived in Scotland for much of his relationship with Small but corresponded regularly with Small up until his early death, forming a significant friendship and, ultimately, a mentorship.

Small took a serious interest in Watt's innovated ideas on how to redesign the steam engine. In Small's first letter to Watt on 7 January 1768, he expresses his interest in his ideas and desire to help facilitate his work, "... my idea was that you should settle here, and that Boulton and I should assist you as much as we could...in a partnership that I liked I should not hesitate to employ any sum of money I can command on your scheme" (Qtd in Muirhead 17). An eventual partnership was worked out between these Lunar men, but beyond that, Small and Watt regularly corresponded where Small's primary role became advisor and encourager. A year after they first started corresponding, Watt's patent for his steam engine was approved but required that he complete the specifications in a four-month period. Throughout this time, the letters between Watt and Small were dedicated almost entirely to the drafting of the patent specifications, much of which came from Small (Schofield & Hull). Even with the help drafting the patent, Small's most important influence on Watt was his encouragement to not give up. Small writes in a letter to Watt, "you have as much genius and as much integrity or more than any man I know" (Qtd in Hull 104). Without Small's encouragement, the partnership between Boulton and Watt may never have happened and the result would be a significant loss to industrial advancements during the late eighteenth and early nineteenth centuries.

Watt and Small corresponded about many other scientific inquiries beyond Watt's personal work with the steam engine theorizing about advancements in chemistry such as Carl Wilhelm Sheele's hydrofluoric acid discovery, Joseph Priestley's work on metal vapors to far fetched discussions of geology. One such geological inquiry suggested the need to blow up the polar icecaps and direct them to torrid climates to aid in producing more temperate conditions (Schofield *The Lunar* 102). This outlandish idea actually was adapted and discussed by Darwin in his poem, *Botanic Garden.* Small's discussions of science with his friends were unending, amusing, and most of all, influential in their future endeavors. Watt recognized the importance of Small's influence and steadfast friendship as he writes in 1772, "there is no [person] to whom I have so fully explained my inmost thoughts as I have done to yourself and I have no fear of ever have cause to regret it" (Qtd in Hull 104). Eventually, due to the persistence of both Small and Boulton, Watt decided to move to Birmingham from his home in Scotland and take a position working with Boulton while also becoming a more regular and active member of the Lunar Society.

In addition to Small's close friendships with Boulton, Darwin, and Watt, he was regularly associated with and influenced multiple members of the Lunar Society such as Wedgwood, Kier, Edgeworth and Thomas Day. For example, Small met Day through his acquaintance with Edgeworth and participation in the Lunar Society and had a lasting impact on his life. Day, young and not particularly inclined to the physical science exploration that many of the members of the society were involved in, found a way to lend support as he was interested in the pursuits. Day lent money to help support one of Small's ventures with other Lunar men (Schofield *The Lunar* 51). Day was interested in pursuing medicine for a career and received advice from Small. Small advised him that "the practice of medicine would neither make him happy nor, as he would do it, would it help mankind" and thus Day decided to follow a different route and pursue his inclination towards philosophical reform (Schofield *The Lunar* 54). Day's choice to avoid the field of medicine at the behest of Small provides an additional example of how Small's advice was held to the utmost level of importance. Small had friendships with all the men of the Lunar Society and imparted advice regularly on both matters personal and professional. The men of Birmingham relied heavily on the wealth of knowledge shared by Small in his short time residing there.

Small contracted Malaria early in his life while holding his post as Professor at the College of William and Mary. Many historians claim that part of the motivation to return back to England was to escape the climate in Virginia that was detrimental to Small's health. Small was often sickly and especially suffered during 1774. Ultimately on 25 February 1775, under the care of Darwin, Small passed away from what, at the time, was diagnosed as "putrid or jail fever" at the age of 40 (Craig). Darwin, in a letter to William Withering, writes of Small's passing and the immeasurable loss he was feeling at the time,

> I am at this moment returned from a melancholy scene, the death of a friend who was most dear to me, Dr Small, of Birmingham, whose strength of Reasoning, quickness of Invention, Learning in the Discoveries of other men, and Integrity of Heart (which is worth them all), had no equal. Mr. Boulton suffers an inconceivable loss from the Doctor's mechanical as well as medical abilities. (75-1)

Darwin's sentiments are seconded by many, including close friends Boulton and Watt. Boulton wrote of Small's failing health and the toll it was taking in a letter to Lord Dartmouth on 2 February, just weeks before Small's death. Boulton writes,

> The spirit of my politiks hath lately been absorbed by my anxiety for my dear friend Dr. Small...His virtues were more and his foibles fewer (for vices he had none) than any man I ever knew. The public will sustain in

> his death a loss. I shall sustain a great and irreparable one… (Qtd in Schofield *The Lunar* 116)

Boulton's anxieties turn to reality as he writes to Watt on the day of Small's death, "...I have this evening bid adieu to our once good and virtuous friend for ever and for ever. If there were not a few other objects yet remaining for me to settle my affections upon, I should wish also to take up my lodgings in the mansions of the dead…" (Muirhead 81-82). The despair felt in the words of Small's close friends is evidence to the incredible affect and influence he had on their lives.

Thomas Day, a member of the Lunar Society and friend of Small composed an elegy on the death of Small. Day had unsuccessfully attempted to return back to Birmingham from Brussels when he heard of Small's ill health. Out of despair at missing the opportunity to be at his bedside, Day writes in "Epitaph of Dr. Small of Birmingham,"

> When all the noblest gifts that Heaven e'er gave,
> Were destined to a dark untimely grave
> ...
> Thy dear remains we trust to this sad shrine,
> Secure to feel no second loss like thine! (Qtd in Seward 24)

Like Day, Darwin too felt it cathartic to mourn their great loss through poetry. Darwin composed an elegy in remembrance of Small that was then engraved onto a vase and placed in a special spot in Boulton's garden. Seward includes Darwin's four stanza elegy in her *Memoirs*. The last stanza reads:

> Cold Contemplation leans her aching head,
> And as on human woe her broad eye turns,
> Waves her meek hand, and sighs for science dead,
> For science, virtue, and for Small she mourns. (Qtd in Seward 23-24)

Darwin is not just mourning the personal loss of a friend. His language goes beyond that. He speaks to the loss that science was dealt with the early passing of Small. Small had interests that were documented in letters from metallurgy to chemistry to geology to the workings of clocks and telescopes among so many others. What more could he have offered science if only he had lived longer? Small had many friends, and all including numerous Lunar men not mentioned praised his character, personality, and wealth of knowledge. His loss was significant for the men of the Lunar Society and consequential in its future establishment and success.

William Small's death in 1775 appears to be what solidified the function of the society moving forward. Small was the glue that held friendships and scientific discourse exchange together—keeping the possibility of a society alive and it was his death that forced the need to create more regular and set meetings (Jones). Schofield also supports the notion that Small's death was a catalyst for the solidification of the society, while also noting that there is little doubt that Small brought these men together;

> A society does not develop spontaneously out of nothing, and it seems reasonable to suggest that the Lunar Society sprang from the group which Small had linked together; there is some cause to suggest that it was the death of William Small, threatening the dissolution of that group, which led to the more formal organization of a society meeting regularly. ("Membership" 126).

Additionally, the first real mention of a meeting of Lunar men comes just months after Small's death in a letter from Darwin to William Withering, the medical doctor who took over Small's practice after his death (Schofield *The Lunar* 141). Small is often credited as a founding father of the Lunar Society for the role that he played in connecting so many different men, yet all these men were linked through business or leisurely interests. Just as Jefferson praised Small for his ability to communicate with ease, this trait and his good nature are what brought the Lunar Society into prominence.

Members of the society often reflected on Small's good nature. Richard Lovell Edgeworth writes that Dr. Small was

> a man esteemed by all who knew him, and by all who were admitted to his friendship beloved with no common enthusiasm. Dr. Small formed a link which combined Mr. Boulton, Mr. Watt, Dr. Darwin, Mr. Wedgwood, Mr. Day and myself together--men of very different character but all devoted to literature and science. (Qtd in Smiles 148)

Small's character and friendships with so many brought together the most influential men in Birmingham forming the significant collective of the Lunar Society, facilitating a connection between many that led to innovation and scientific advancement. Further, Francis Galton in *Hereditary Genius* writes of Small and describes how

> some eminently scientific men have shown their original power by little more than a continuous flow of helpful suggestions and criticisms, which were individually of too little importance to be remembered in the history of Science, but which, in their aggregate, formed a notable aid towards its progress. In the scanty history of the once well known "Lunar Society"...there is frequent allusion to a man of whom nothing more remains, but who had apparently very great influence on the thoughts of his contemporaries--I mean Dr. Small. (193)

Small, unlike most members of the Lunar Society, was never made a Fellow of the Royal Society, nor did he become renowned for his inventions and scientific advancements. His one patent held was on a singular clock mechanism. There is such little even remaining of William Small's life to appear to warrant much serious scholarship beyond his associations with some of the most prominent scientific figures in the Romantic period. Yet, it is just that—his relationships, friendships, mentorships; ultimately, his camaraderie with these men warrants the need to recognize him for his contributions to not only the collective of the Lunar Society, but to science as a whole. William Small created the initial space and was the catalyst for bonds and friendships among influential scientific men in Birmingham and greater Britain; thus without Small, it is not far-fetched to claim that there would never have been a Lunar Society or a collective of men of the likes of Darwin, Boulton, Day, Wedgwood, Kier, Priestly, Watt, Galton, and so many others. His tenure among the men in the society was brief. Yet, his influence is seen far beyond any physical production. Small's contemporaries reveled in his friendship and recognized his invaluable additions to their work. Anna Seward in *Memoirs of Darwin* while describing Darwin's friends and acquaintances in Birmingham claims that "And above all others in Dr. Darwin's personal regard, the accomplished Dr. Small, of Birmingham, who bore the blushing honours of his talents and virtues to an untimely grave" (16). There is nothing surprising about Seward's claim of Darwin's regard for Small as he often referred to him in letters as his "favourite friend" (King-Hele 131).

William Small represents a key part of the network of the Lunar Society. He facilitated friendships, business deals, and creative invention. He was central to the web of scientific curiosity and discovery present in Birmingham and greater Britain in the Romantic period. He was not the most famous, or most productive in a publication sense; yet, his role in the society was essential to the success of the collective, and helps to emphasize the important role of these men in science in the late eighteenth and nineteenth centuries. A scientist was not just a man in a white lab coat. Small shows how the scientist comes from a place of exploration and insatiable curiosity. He along with the other proto-scientists of the Lunar society are representative of the men who popularized science and brought it to the forefront of culture, emphasizing its important role in society and showing off its power. These men were essentially scientists and although they lived before the term came to be that would one day represent them, they did not need to be isolated in their studies to put science in action. Ultimately, it is the science of these men, ideas discussed, debated, and supported by a community that we see science and scientists returning to today. A varied knowledge helped these men to be more successful in their inventions and scientific pursuits. The decade long debate between whether the society's goal was to drive industry or whether its existence was a mere product of the enlightenment thinking fails to step back and see the real important influence of the Lunar Society. Undeniably, whether as part of the industrial revolution or as a result of enlightenment thinking, the Lunar Society influenced a generation of new and budding scientists whose inventions and discoveries are still important today.

The X Club of Victorian England

Forming clubs has already been established as commonplace during the nineteenth century, but the motivations for such gatherings differed from the early to late century. Charles Darwin's publication of *On the Origin of Species* created a backlash in society against the heresy of science and pushed, or rather, united many scientists together to defend the theory, and other scientific pursuits, against religious backlash. In part, as an attempt to establish men of science as a more authoritative voice within society, colleagues and friends came together to form the X Club. The religious leanings of the club members varied from atheist to devout Anglican; however, the feelings of the group to keep the Church out of scientific pursuit was uniform. Barton argues, “The X Club members rejected the implication that science needed legitimation from any other authority. In their view, science carried its own authority” (2). Tyndall, a member of the X Club, writes about the people’s desire to hear a new authority figure, one that was not heralded by politics or the church, but rather by science; “I hear from various good men and true that they are tired of the professional politician...and wish to hear the free and unbiased sons of science speaking out” (Qtd in Jensen 71). This was one of the primary motivations of the members of the X Club and speaks to the causes that ultimately joined them together.

Just as the Lunar Society was ultimately established on friendships, so too was the X Club. Victorian England had numerous scientific societies one could be a part of in addition to the Royal Society. Yet, they lacked in a way that drew these established and well connected scientists together beyond their initial friendships to establish a scientific club. The first discussion that would evolve into the X Club was an exchange between Joseph Hooker and Thomas Huxley. Hooker explained his disappointment to Huxley about rarely having the time to meet with his fellow scientists outside of work time: “I am very glad that we shall meet at Darwin’s. I wish that we could there discuss a plan that would bring about more unity in our efforts to advance Science” (Hooker 369). Huxley seconded Hooker’s feelings and responded by organizing a meeting of scientific friends. Thomas Archer Hirst recorded evidence of the first meeting of what would become the X Club; Hirst writes,

> On Thursday evening Nov. 3, an event, probably of some importance, occurred at the St. George's Hotel, Albemarle Street. A new club was formed of eight members; viz: Tyndall, Hooker, Huxley, Busk, Frankland, Spencer, Lubbock, and myself. Besides personal friendship, the bond that united us was devotion to science, pure and free, untrammelled by religious dogmas. Amongst ourselves there is perfect outspokenness, and no doubt opportunities will arise when concerted action on our part may be of service. (Qtd. in Jensen 63)

Spottiswoode, a longtime friend of Tyndall, was invited to join the Club after its first meeting. As all members were connected first through friendship, Spottiswoode fit the bill. However, he also filled a dearth in members who studied the physical sciences, and thus his admittance into the X Club added to the breadth and evenness of the members divided between fields of science. Although the main purpose of the club was not formalized, the informal purpose of the club was to "further the cause of science" (Jensen 64). Saba Bahar argues how "these professional men of science were eager to promote...a new ideology of science...They wanted to lift...science...from a mere craft to the status of philosophical and legislative authority" (41). Established and talented friends within the scientific community wanted to gather together to discuss the future of science and how they could play a more active role in determining the path it followed.

The nine members of the club became some of the most influential and powerful men in science during the nineteenth century. George Busk (1807-1887) was the oldest member of the club at the age of 57 at the initiation of the meetings. He was a retired naval doctor, but in retirement from the navy found himself able to pursue his more experimental passions, as he was researching the cutting edge practice of craniometry at the Royal Institution while also holding an administrative position at the Linnean Society. Edward Frankland (1825-1899) was one of the physical scientists in the club and held a professorship of chemistry at the Royal Institution while also lecturing in chemistry at St. Bartholomew's Hospital in London. His chemical experiments landed him a salaried position evaluating and analyzing London's water (Barton 2). Thomas Archer Hirst (1830-1892) also made up part of the physical scientist constituent of the club as he specialized in mathematics and physics, eventually taking an appointment for a professorship at University College. He is most known for his well-documented minutes of many X Club meetings even though there was no official secretary. Joseph Hooker (1817-1911) was a botanist and the Assistant Director of the Kew Gardens (Jensen 64). As mentioned earlier, his yearning for a group to attend to discuss science among others outside of work, which he expressed to Huxley, was one of the catalysts for the forming of the X Club. Thomas Henry Huxley (1825-1895) was probably the most famous member of X Club and often referred to as "Darwin's Bulldog" for his staunch support and popularizing of Darwin's evolutionary theory. Huxley was Professor of Natural History at the Government School of Mines and organized the first meeting of the X Club. John Lubbock (1834-1913) was a banker by trade as he came from a wealthy banking family, but he studied with Darwin and considered himself a naturalist while he also made his own strides in the study of archaeology (Barton 1). Herbert Spencer (1820-1903) was most notable for his role as science writer and popularizer, but also made significant contributions to theories in philosophy, psychology, and sociology. His life and work will be looked at more closely later in this chapter. William Spottiswoode (1830-1892) was the last added member to the X Club. He was a trained mathematician and principal at the Queen's printer, Eyre and Spottiswoode. And the last member of the

X Club was John Tyndall (1820-1893) who was a professor of natural philosophy at the Royal Institution and renowned for his entertaining and brilliant lectures, which were attended by many (Barton 2).

The original eight members were looking to add a tenth member after Spottiswoode joined, but "as Spencer later recalled, no one was found who fulfilled the two requirements—that he should be of the adequate mental caliber and that he should be on terms of intimacy with the existing members" (Macleod 309). There existed other clubs and societies for men to join to discuss science. This particular club fulfilled a more important purpose as it provided a level of intimacy among friends that bore the possibility of more fruitful and unfiltered discussions of science and its fate within British society. Additionally, the X Club, like the Lunar Society, was not as concerned about position or class as they were about the individual's contribution to scientific conversation. Men of the X Club preferred the term "scientific men" to the previous gentlemen of science because it focused less on class status and pointed more to "middle-class gents" who were defined based on "truthfulness, courage, and character rather than rank" (Desmond 13). This shift in view of who was involved in science was quite important for the X Club members and the future of science and the scientist as the need to democratize science to men outside of the leisure class was important. Recognizing the burden of cost associated with much of the established institutions at the time, it is not surprising that under tenure of an X Club president the Royal Society removed the entrance fees (Barton 2). This removal of fees opened up the possibility of more in the middle class to participate in all that the Royal Society had to offer. Most of the members of the X Club were born into the middle class without position; and they all recognized the role of science for the people, outside the elite for which it was traditionally reserved.

Just as the men of the Lunar Society invited guests to join them at table as they passed through Birmingham, X Club members also invited notable scientific men to join them on occasion. Membership in the club was limited, but the occasion to engage with another bright mind was encouraged. Visitors to the club included evolutionary theorist Charles Darwin, French engineer Auguste Laugel, German physicist Hermann von Helmholtz, American botanist Asa Gray, and American geologist Louis Agassiz (MacLeod 312). The X Club was known widely and was an attractive opportunity for any man of science to participate in when invited.

The members used the meetings as a forum to discuss and critique their current work and experiments. For example, Hooker's minutes of the meetings discussed members' individual work such as "the reflecting of blue rays of the molecules of attenuated vapors" that Tyndall had discovered (Qtd in Jensen 69). Beyond just providing critiques, the members also sought to help each other in their individual endeavors when the opportunity arose. Before one particular meeting, Huxley requested that Tyndall bring a specimen of bacteria with him "to the 'x'" as he writes, "It will be useful to you I think if I determine the forms with my own microscope and make drawings of them which you can use" (Qtd in Jensen 69). Huxley recognized an opportunity to help a fellow member and reached out.

The members of the X Club believed fervently that science was not only separate from religion, but that the supernatural played no part in science. This belief in science was a core focus of the members of club and the idea of naturalism, or rather the uniformity of nature, was the theory the X Club used to focus their future of science away from the church and the belief in the supernatural. This was important for their ideas about the foundations of science and its methodologies. Barton argues that "They opposed all suggestions that there were supernatural interventions in the natural order and any attempts to constrain scientific investigation within theologically determined boundaries" (56). Huxley was one of the most outspoken members of the club and he explains this naturalistic position as such:

> The fundamental axiom of scientific thought is that there is not, never has been, never will be, any disorder in nature. The admission of the occurrence of any event which was not the logical consequence of the immediately antecedent events, according to those definite, ascertained or unascertained rules which we call "the laws of nature" would be an act of self destruction on the part of science. (*"Scientific"* 196)

Huxley's argument against the supernatural in science was unwavering. Essentially, a discipline's "insistence on unbroken law" made it scientific, and ultimate scientific progress was found in the continued rejection of the supernatural (Stanley 541). Beyond the need for naturalism to fulfill the defined view of science that the X Club members held, the focus on naturalistic science was also important to the members because it meant that the church was no longer an authority in science, allowing room for the professional scientist to rise to a new power, nor was the church, then, the right group to control positions and institutions in science (Stanley 540).

As a group, the X Club was incredibly influential on the future of science through their active role in science education. Many members were teachers (Tyndall, Hirst, Huxley, Busk and Franklin) while others served in administrative roles (Huxley served on the London School Board among other positions) and with the Elementary Education Act passed in 1870, there was a need for a defined science curriculum and members of the X Club stepped in to help fulfill the need (Desmond 12, Stanley 553). Because of their dominant role in the formation of science education, the X Club members could more readily guarantee that the naturalistic view of science was taught in the classrooms. Additionally, their role in education went beyond just teaching the youth, but the advancement and professionalization of science, which the X Club helped herald in, meant the need for more defined disciplined university departments. X Club members helped fill and recommend naturalistic scientists for professorships and positions (Stanley 553). Their influence can be traced through generations of people through naturalistic science education. The influence on science education and therefore on science in the Victorian period shows the significant role of the X Club on the science network.

The X Club members lived in a Victorian society that was much advanced in regards to science compared to the Romantic period for the Lunar Society. The scientist was an established term becoming more popular and used to describe professional men of science[4]. Their roles in the X Club were not due to an absence in opportunity to participate in other scientific societies. Multiple members were quite prominent scientists

[4] See previous discussion of William Whewell and the origin of the term scientist in 1833 in the introduction. For more information, see also John Van Whye's "William Whewell (1794-1866), gentleman of science" *Victorianweb.org*

and held esteemed roles in the most prestigious societies. For example, Hooker, Huxley, and Spottiswoode were all at one-point President of the Royal Society and the British Association for the Advancement of Science (Barton). The X Club members regularly conversed about issues concerning the happenings of the Royal Society. The reason for this was dual in nature as many (all but Spencer) were members of the society and held leadership roles. But more importantly, meetings were practical and convenient for attendees to discuss the society's affairs because the X Club chose its meeting night and time, even the location of the X Club, to correspond with the general meeting of the Royal Society. The X Club would meet for dinner at the St. George's Hotel, which was nearby the Burlington House where the Royal Society meetings were held around 8 in the evening (Jensen 66). Additionally, the X Club members were also highly involved in the British Association for the Advancement of Science and would regularly discuss the inner workings of the society at meetings. Even though Spencer was not a member of this society, he would still often attend the annual conference as the X Club used it as a way to travel and have a united front.

Membership in the X Club only advanced their roles and varied positions in the formal scientific societies. The X Club provided a fraternity of like-minded and respected scientific men where meetings provided the space to come together amongst friends and colleagues and openly discuss the future of science with a freedom nonexistent in the formal societies. The informal nature of a supper club, as the X Club was deemed, created a place to discuss ideas about science, which could then be advocated for in the more formal scientific society setting. Although membership in the club was quite limited, the men of the club were able to use their resources and allies to help advance their ideas. For example, the members of the X Club lobbied against the conservative candidate G. G. Stokes so that their own Spottiswoode would assume the role of President of the Royal Society after Hooker. This would guarantee their power in the Royal Society for another presidency. Additionally, they gathered together and rallied behind Hooker in helping him maintain control over Kew Gardens when a government employee, the first commissioner of works, attempted to garner control (Barton 3). Whether the reason was for the individual member or for the betterment of science as a whole, the friends and members of the X Club would stand together and created a force of power and influence during the latter half of the nineteenth century. This fraternity of men was able to master the puppet strings of so much of the scientific community that their goals in advancing science to a new state of authority became realities.

Starting in the mid 1880s, regular attendance began to diminish in the X Club marked first by the death of Spottiswoode in 1883. Adding to the struggling attendance is a dispute that occurred between two members. In 1889, differences of opinion once held to friendly banter exploded into animosity between Spencer and Huxley. Spencer rejected initial attempts from Huxley to compromise to the distress of its other active members. However, years later, the dispute was settled, but at this time Spencer was in rare attendance at meetings due to his failing health. There was discussion to add new members to the club to fill the void created by ill health or death, but it was ultimately rejected (MacLeod 313-15). The X Club officially dissolved after its final meeting in March of 1893 mostly due to poor attendance. The tenure of the X Club as an informal club of science's elite was long and influential. Arguing the specifics of the authority wielded by the members is impossible, but their influence pervaded numerous aspects of scientific culture and their power in the multiple societies was great.

Herbert Spencer, X Club Member

Herbert Spencer was born in Derby in 1820 to a middleclass family. His father had tried his hand at a manufacturing business but failed and took on the profession of instructing pupils. His father, though, was the secretary in the Derby Philosophical Society and thus Spencer was exposed to a more open and free-thinking intelligentsia at a young age. He describes the influence of his father's personal philosophies on life and the outlook he had hoped to convey to his son in his autobiography (Harris 2). There is no doubt that the philosophical talk of Spencer's childhood played a role in the development of his own philosophical theories. Spencer struggled to find a passion or the desire to put in hard work and did not have a set profession until his late twenties. Spencer's initial profession was not in science nor did he show to have much of a real proclivity for it at a young age. He did realize though that he was more inclined to philosophy and theorizing ideas rather than the practical applications of such (Harris 4). He at, one time, studied civil engineering, but ultimately found his literary endeavors most appealing. His future path was set during his time as a sub-editor at *The Economist*. Spencer had interesting theories conceiving society as a "co-operative, cross-class, self-regulating organism, tended to at a distance" but his own theorizing would take a backseat as he realized a need for someone to help articulate and translate the philosophical and scientific debates he was witnessing in the late 1840s (Harris 5).

The rise and professionalization of science combined with higher literacy rates and a more informed public created a space for those interested and knowledgeable of science but who did not necessarily partake in the practice and experimentation of science to gain authority and popularity. These were science journalists, or popularizers of science who wrote about science rather than being practitioners of science. Popularizers provided the way for science to be consumed in mass quantities by the general literate readership; popular science texts were a way to influence the readership on what science was while also growing the popularity of science.[5] Herbert Spencer, in the role of science writer, was invaluable to the X Club and science in the Victorian era. Spencer's role of bridging the space between public and scientist was exceptionally important because as Lightman argues,

> as science became professionalized and professional scientists lost touch with the public as they began to pursue highly specialized research, a market emerged for popularizers of science who could convey the broader significance of many new discoveries to a rapidly growing Victorian mass readership. ("Marketing" 101)

Spencer was similar to William Small as much of his notoriety was not for his own particular practice or discovery but because of his influence and ability to appropriate and translate ideas. He was a popular writer of science and thus he brought the scientific ideas of his peers to the literate public. The X Club had a science writer colleague and

[5] The role of female popularizers of science will be discussed in detail as a collective of influence in chapter three.

confidant in Spencer who could help convey and publicize their more specialized work to a general and interested readership. Yet mere popularizer and science writer are insufficient titles to give Spencer because his contributions go beyond.

Unlike many popularizers, Spencer was much more closely allied with professional science as he did not just write about others' theories of science, but he postulated many of his own as well. Spencer's most famous philosophical endeavor was the nine-volume *A System of Synthetic Philosophy* that applied evolutionary theory to matters of psychology, sociology, and philosophy (Sweet). This theorizing of his personal philosophy took him over 40 years to complete, twice what he had originally hoped. In addition to his magnum opus, he published two full length books, *Social Statistics* (1850) and *The Principles of Psychology* (1855). Spencer would later update his second book to become part of his larger endeavor in *Synthetic Philosophy*. Although at times he needed financial rescuing from friends and colleagues due to a lack of income, as a whole, his publications (both full length and essays, which were numerous) were highly popular internationally and ultimately left him with a considerable income later in life. Spencer is often referred to as the father of evolutionary psychology for the work he completed, but much of his notoriety is conflated with his social network of fellow eminent scientists and philosophers during his life.

Spencer was a member of the X Club from its initial meeting. He documented his attendance at the meeting in a letter to his father when he wrote,

> In pursuance of a long-suspended intention, a few of the most advanced men of science have united to form a small club to dine together occasionally. It consists of Huxley, Frankland, Tyndall and Hooker,

> Lubbock, Busk, Hirst and myself. Two more will probably be admitted, but the number will be limited to ten. (Spencer *Autobiography* 133)

Spencer was one of the last living members of the club and his interest in philosophy and theorizing society through his many publications added a unique perspective. Spencer, like Small, was the only member of the X Club that was not a fellow of the Royal Society, nor was he a member of the British Association for the Advancement of Science. In fact, Spencer regularly refused nominations for membership in prestigious associations, positions at universities, honorary degrees, and awards due to his personal disinclination towards them (Harris). Although not active in the institutions of his peers because of his personal philosophy, he was quite knowledgeable of their inner workings and happenings from the other members of the X Club.

Spencer found support amongst his friends in the X Club when it came to his publishing endeavors. Although his first attempt at a literary and scientific journal, *The Reader,* was ultimately unsuccessful, its failure was in no part due to a lack of support from his scientist colleagues. Many of the X Club scientists and members wrote and contributed articles for *The Reader* while it was in circulation. However, his second attempt at such a journal was not only again supported, but it was the support from his X Club peers that helped establish and carve a pathway to success. Spencer wrote to the publisher Youmans in 1867 about how "an attempt is being made here to establish a scientific journal, to do what *The Reader* was intended to do...I mentioned it at the X, and the notion was well received. I propose that we shall take a year or so to organize matters, before making a start" (Qtd in Jensen 68). Scholars suggest that this scientific journal described by Spencer is what would become *Nature* (Jensen 68). The members of the X

Club regularly contributed to the journal throughout its first few years. Even Huxley and Tyndall extended their support beyond contributions in written form as they served alongside Spencer as advisors for the *The International Scientific Series* (Lightman 105). Spencer again received significant help from his X Club friends when they "subscribed to 250 copies of [his] *System of Philosophy* to save their colleague from financial embarrassment" (MacLeod 311). Although the individual members of the club may have aspired to achieve greatness and notoriety in their own fields, they were first and foremost friends and through the unity of the club they strengthened those connections and helped each other in their times of need.

One of Spencer's earliest ideas regarding evolution and human population garnered more acclaim than one could have expected when it was appropriated by Charles Darwin and used in his seminal publication *On the Origin of Species.* Darwin appropriated Spencer's term 'survival of the fittest' and incorporated it in his discussions of natural selection. The chapter title for natural selection in *On the Origin* also included the term: "Natural Selection; Or The Survival of the Fittest" (Darwin 93). Spencer used the term in a discussion of human evolution and implied that it spoke to the progress of the species. This, however, differed from Darwin's use of the term. They were in agreement that it was about the struggle for existence and those with more favorable adaptations survived—thus 'survival of the fittest'. However, as Huxley, or "Darwin's Bulldog" noted, "the unlucky substitution of 'survival of the fittest' for 'natural selection' had done much hard in consequence of the ambiguity of 'fittest'—which may take to mean 'best' or 'highest'—whereas natural selection may work toward degradation…"

(Qtd in Rogers 159). Darwin was not using the term to equate with progress in the positive sense as Spencer was. Spencer's application was less biological and more social as it supported his philosophy about society. Spencer used the term in his *Theory of Population* (1852). This societal application of the term highly influenced the Social Darwinist movement who appropriated the term and applied Darwin's theory of evolution to society. Spencer's belief that the survival of the fittest was ultimately for the greater good and "the poverty of the incapable, the distresses that come upon the imprudent, the starvation of the idle, and those shoulderings aside of the weak by the strong, which leave so many 'in shallows of miseries' are the decrees of a larger far-seeing benevolence" would be adapted by the Social Darwinists as a misconception of Darwin's theory (Spencer 322-23). Yet, it followed with Spencer's philosophical stance about society, and the Social Darwinists, then, brought that to greater popularity (Rogers 160-62). Spencer's influence on Social Darwinists was great and they were a driving force during the Victorian period. Even without practical science and innovation, Spencer's theories affected many and could be felt throughout the scientific community. He was more than just a popularizer of science as his own theories, too, were not only published, but well received.

A close reading of one of Spencer's early essays, short yet seminal, allows for a better understanding of his great contribution to nineteenth century science and his lasting influence on the science network. First published in *The Leader* in 1852, Spencer's essay "The Development Hypothesis" is a concise discussion against creationism or what he calls the idea of "special creation," in favor rather of an evolutionary theory of creation through adaptation. "The Development Hypothesis" was written in direct response to a debate taking place about the idea of evolution and those that reject the transmutation of species in favor of special creations. Spencer was absent from the debate and thus uses his publication as a medium through which he could add to the discussion while also have a space to articulate his own ideas about evolution.

He begins the essay reacting to a statement supposedly made by those in favor of special creation, which argued that transmutation of species was unphilosophical. Spencer responds, "I should have replied that, as in all our experience we have never known a species *created*, it was, by his own showing, unphilosophical to assume that any species ever had been created" (35). He quickly assumes both an assertive and sarcastic tone. He is firm in his presentation of the argument and his theory while his discussion of the opposition is lined with a biting lambastic connotation. He describes, based on the work and figures presented by Humboldt and Carpenter, that there, roughly estimating, are or at one point existed at least 10 million different species of plants and animals. He follows this figure with, "Well, which is the most rational theory about these ten millions of species? Is it most likely that there have been ten millions of special creations? or is it most likely that, by continual modifications due to change of circumstances, ten millions of varieties have been produced, as varieties are being produced still?" (35). This is his first mention of some aspect of his theory of evolution—one that revolved around the idea of mutation and adaptation over expansive periods of time. His reliance on rational thought, or what appears even most plausible, is a line he takes throughout the entirety of his essay. He never out rightly says that the opposition is irrational, but he is able to imply such in a way that was not overtly abrasive.

He addresses the counter argument, but boils it down to the fact that one can only want to believe that these special creations number in the tens of millions, because, in reality, “men do not really believe, but rather *believe they believe”* since “careful introspection will show them that they have never yet realized themselves the creation of even *one* species” (35). Spencer then lists illogical ways that special creation may exist such as “thrown down from the clouds”, “it struggles up from the ground” or that “its limbs and viscera rush together from all the points of the compass” (35). He does this to prove the level of absurdity that he associates with the idea of special creation. He begs his opponents to come forward, then, with a theory of how special creation takes place that does not appear as absurd as his examples. This leads Spencer to set up his last real issue with the fact that the debate between these two camps even exists. He points out that the people in favor of special creation “are merely asked to point out a *conceivable* mode. On the other hand, they ask, not simply for a *conceivable* mode, but for the *actual* mode. They do not say--Show us how this *may* take place; but they say--Show us how this *does* take place” (35). This is a real point of contention for Spencer because of the inequity involved in the mere set up or format of the discussion between these opposing views on creation. He finds it preposterous that those in favor of special creation are not held to the same standard of truth and proof as those that choose to acknowledge the idea of the transmutation of species. In response, then, to this frustration of his, he continues with his argument for adaptation through mutation; he readily provides multiple examples that offer on a minute scale, models for how transmutation of species exists on a larger scale. Thus, he is essentially giving the camp in favor of special creation multiple conceivable modes for the existence of his theory. He is meeting the burden of proof that they are ascribed to when asked to provide details on the method for special creation.

Spencer argues that not only can those in favor of the Development Hypothesis provide a conceivable example of its existence, but they can do more than that, "They can show that the process of modification has effected, and is effecting [sic], decided changes in all organisms subject to modifying influences" (36). Now, he recognizes that this group cannot provide a directly traced line of how a specific organism adapted from one cell through all of the stages to end up at its current state, which is a slight drawback. But, he claims that

> they can show that any existing species--animal or vegetable--when placed under conditions different from its previous ones, *immediately begins to undergo certain changes fitting it for the new conditions.* They can show that in successive generations these changes continue; until, ultimately, the new conditions because the natural ones. (Spencer 36)

The fact that the Development Hypothesis can be shown on a smaller scale shifts the argument wholly in favor of the Development Hypothesis, if it was ever not. Further, he argues that anyone can see the Development Hypothesis in action. All one has to do is move beyond "looking at things in their statical aspect than in their dynamical aspect, [because] they never realize the fact that, by small increments of modification, any amount of modification may in time be generated" (36). He discusses how one feels when they have been absent for years and return to see who was once a small boy now as a man. People, regardless of their camp, do not deny that change has occurred, yet he then complains to the fact that when looked at on a much greater scale, what is once undeniability "becomes incredulity" (36).

Spencer provides three main examples in support of the Development Hypothesis that provide a small scale model for the transmutation of species favored in the theory. He starts with the comparison of a circle versus a hyperbola arguing that there appear to be no similarities between a circle and a hyperbola—very easily stated, they are not the same. He then presents a cone, and shows how when a cone is "cut by a plane of right angles" it produces a circle (37). Spencer moves through the various angles at which you can cut a cone that will ultimately produce for you a hyperbola. So he argues,

> here we have four different species of curve—circle, ellipse, parabola, and hyperbola—each having its peculiar properties and its separate equation, and the first and last of which are quite opposite in nature, connected together as members of one series, all producible by a single process of insensible modification. (Spencer 37)

His use of mathematics is smart because he presents the process outside of biology but makes such a clear comparison that when applied to biology, it is absurd that one would automatically discount it.

His second example is much closer to the issue at hand for many as he uses the process of a seed and how it ceases to be a seed as it evolves into a tree, a tree that in no way resembles the one-time seed that it came from. He quickly, then, moves into his final example: the idea of human development. The original state of a new human being is so small that it is naked to the human eye, and even if looked at under the microscope for minutes, one would not see the change in development. Yet after a series of time, a baby is born who then grows to adulthood. A human being formed out of a cell. An example from which it is hard to find someone in dispute of its accuracy. Yet, as necessary, Spencer sarcastically ends the example with the fact that "the uneducated and ill-educated should think the hypothesis that all races of beings, man inclusive, may in process of time have been evolved from the simplest monad, a ludicrous one, is not to be wondered at" (37). His language is cutting but it is quite difficult not to be in agreement with him because of the evidence that he provides to his readers. His last real statement on the matter before he ends with a direct attack on those scientists that still choose to deny evolutionary process, is straightforward and exacting on the Development Hypothesis. He says, "surely if a single cell may, when subjected to certain influences, become a man in the space of twenty years; there is nothing absurd in the hypothesis that under certain other influences, a cell may, in the course of millions of years, give origin to the human race" (Spencer 37). His language is key here because he moves past talking about animal and vegetable species as a whole to directly speaking about the more controversial nature of human origin and evolution.

Spencer ends his essay with a direct attack on other scientists who continue to believe in the idea of "special creation". He uses the idea of the Mosaic account of creation, which takes the Genesis story of creation in the literal sense—the formation of the earth out of chaos and all of its creation in a mere week—to set up his argument against these scientists. Particularly he calls out the geologists and physiologists who would scoff and be insulted if they were assumed to believe in the Mosaic account, which they now would either have rejected entirely, or "understand it in some vague non-natural sense" (Spencer 38). Yet, these scientists still take special creation to be an accurate representation of the existence of species and humans. Spencer's frustration culminates in the end of his essay where his final statements continue to question the preposterousness of the belief that not only those "uneducated or ill-educated" but those of science choose to continue to support the theory commenting,

> he has not a single fact in nature to cite in proof of it; nor is he prepared with any chain of reasoning by which it may be established...and why, after rejecting all the rest of the story, he should strenuously defend this last remnant of it, as though he had received it on valid authority, he would be puzzled to say. (37-38)

This concise piece of writing shows the power of Spencer's literary abilities. Regardless of one's beliefs, he makes it practically impossible not to see his perspective on the argument at hand.

Ultimately, what can really be taken from this piece as we examine it today is not only his interesting theories of evolution, but more so, the method through which he describes them to the public. Spencer's language was clear and his method for expounding theories made them easily understandable for the public to perceive rather than only using highly scientific and elevated language. This ability was rare in many scientists, and this shows how Spencer was able to bridge the gap between philosopher of science while also being a strong popularizer of science through his ability to relay somewhat difficult theories to a less knowledgeable public. Spencer's own contributions to science and philosophy were strong, but when combined with his ability to provide science to the public through popular writings, his contribution became invaluable and his lasting influence on science in the nineteenth century undeniable.

Spencer suffered throughout his life from anxiety and melancholia, which culminated in a breakdown that left him unable to work for 18 months. After this, he never quite recovered and found himself partaking in more and more reclusive habits. He especially suffered from a lack of ability to withstand the criticism of others. This illuminates more the reason for Spencer's unwillingness to quickly forgive and compromise with Huxley when he publicly denounced him. Huxley, in 1889, referred to Spencer in a letter to Hooker "as a 'long winded vanitous pedant' with 'as much tact as a hippopotamus" during their debate over Spencer's "*a priori* politics and laissez faire extremism" (Desmond 3). Barton notes that it was this publicized debate and feud that led to Spencer briefly halting his attendance and membership in the X Club (4).

Even with reconciliation years later in 1893, the relationship between Huxley and Spencer was never quite the same. Huxley died in 1895 and Spencer's growing desire to stay isolated proved to separate him from many of the remaining members of the X Club. What had once been almost constant correspondence between this club of friends slowly fell away to almost no correspondence at all. Evidence to the falling out of friendships and losing touch is provided by a letter from Spencer to Hooker in 1901,

> 'It is a long time since any news passed between us--a year and a half I think [...] I should like to have a few lines telling me how you fare in your context with the inevitable' (83). Hooker replied in kind and thanked Spencer for this evidence of abiding fellow feeling. '...the dear old Club is rapidly, with us, I fear, approaching the vanishing point. How curious it seems to me that we who were, I think, considered its oldest members, should be amongst the three survivors' (84). (MacLeod 318)

The last years of Spencer's life were spent mostly in isolation away from the friends who had once stimulated his mind. Many of his closest friends had passed away and those he had left, he stayed away from for fear of the realization that his work had been a waste. Beatrice Potter was a close family friend and visited him regularly but claimed it was as if he was "living a living death" (Qtd in Harris 14). Even with his decline in the latter years of his life, his influence on science in the nineteenth century was great. He had the rare ability to make confusing and difficult scientific theories intelligible to the masses. He was nominated for the first ever Nobel Prize in Literature, which speaks to his international influence and acclaim. Even though ultimately Charles Darwin's theories of evolution differed from Spencer's, Darwin writes of him in 1870, "I suspect that hereafter, he will be looked at as by far the greatest living philosopher in England, perhaps equal to any that have lived" (Qtd in Rogers 162). Spencer provides a picture of a Victorian scientist who had varied interests and numerous pursuits. Yet even though his interest in science varied, his life's work was devoted to science whether it was through developing new theories, fathering new fields, or through popularizing the innovation of others. Spencer embodies a Victorian scientist who was involved in science both privately and publicly.

The X Club members were active for over two decades and in that time became, if they were not already, prominent and influential figures in the Victorian scientific community. The influence and power that the X Club wielded was significant. Spencer argues,

> It is not surprising that its influence was felt. Among its members were three who became Presidents of the Royal Society, and five who became Presidents of the British Association. Of the others one was for a time President of the College of Surgeons; another President of the Chemical Society; and a third of the Mathematical Society. To enumerate all of their

> titles, and honours, and of the offices they filled, would occupy too much space. (Spencer Autobiography 134)

Even though the X Club members were also highly involved in the formal societies, their time spent in 'x' meetings with their friends discussing the future of science was invaluable to the establishment of science during the century. Spencer was not the most influential chemist or biologist or botanist. Yet, his theories and his ability to present those of his colleagues to the public was undoubtedly a necessary pillar as to why the members of the X Club were able to be so successful in advancing their goals for science. The power of the members of the X Club to stand together and rally behind science and promote the authority of a scientist for thirty years shows a powerful connection between friends and colleagues. The members of the X Club show that scientists are not the clergy of the church who have claimed public authority, but the hard working actors in the field who are practicing the work daily. This new authority granted to the scientist, which the X Club holds great responsibility in establishing, is one that has been the foundation of science and the science establishment since. These men were able to show the benefit to a science outside of religion, one focused on the natural laws of the universe. Huxley says it best, "It has happened that these cronies had developed into big-wigs of various kinds, and therefore the club has incidentally—I might say accidentally—had a good deal of influence in the scientific world" (Qtd in Jensen 72).

During the nineteenth century, science was blossoming and its breadth growing and the power of the Lunar Society and the X Club emphasized a need that existed outside the few or many formal societies that existed to share ideas among friends or colleagues without the fear of formality or rebuke. The Lunar Society and the X Club also both worked (whether consciously or not) to establish science as a field of pursuit not meant just for society's elite, but for hardworking people. Their role in bringing science to the public is important in how it influences who defines a scientist. A scientist, then, through the help of this collective, is not just a person who comes from wealth and has the leisure to pursue science in their ennui. A scientist can be a man trained in a field, educated at university, or educated through the practicality of daily life, who pursues an understanding of the laws of nature, and therefore science. As science became more professionalized and divided into disciplines and specializations, it also became stronger. Thanks in part to the work of these club members, science became a necessary pillar to a full education. MacLeod argues that it is this change that created a space where 'influential scientific networks began to revolve more around university departments" (318). University and college departments filled a role that clubs once did making them obsolete. The informal scientific clubs like the Lunar Society and X Club, which constitute a significant collective in the science network of the nineteenth century, laid the groundwork for such advancements and without them in the nineteenth century, science would have faltered in its advance to cultural significance and the scientist today would be far different.

The collective influences of the societies help to establish a collective of influence of individual practitioners to scientific insight, offering significant supplements to the professionals of science in the century. As discussed in this chapter, membership in these clubs was limited and exclusive and the scientists discussed are in no way a complete list of professionals of science in the period. Scientists who were members in the Lunar

Society were required to live in or near Birmingham in order to attend meetings. Those in the X Club required a more political inclination as one of their main pursuits was the influence of science in the public. The men discussed in this chapter provide examples of professionals of science, but the emphasis is placed on their club memberships and these scientists are not exclusive. The following chapter provides examples of professionals of science outside the political sphere and outside the role of societies during the century.

TWO

The Collective of Professionals of Science in Nineteenth Century Britain: A Close Reading of Romantic Astronomer Caroline Herschel and Victorian Mathematician and Physicist James Clerk Maxwell

Romantic Professionals of Science

Traditionally, the Romantic period is recognized for its emphasis on the imagination and creativity, and therefore, not on its contributions to the development of science. The terms "natural philosopher" or "*savant*" or "man of science" were used at the time to represent men working in the pursuit of science. Most men practicing science in the late eighteenth and early nineteenth century were forced to take on jobs other than investigation and research for economic purposes. The real exception to this was the gentlemen who married well or were independently wealthy allowing days spent pursuing whatever interests captured their fancy. But without that, many men pursuing science were forced to take on other roles such as teacher, journalist, or physician to pay the bills. For example, "Hermann von Helmholtz who performed pioneering work in physics and physiology, studied medicine for economic reasons" (Otis xx). Referring back to the previous chapter discussing the Lunar Society and X Club, one can see this clearly. None of the men in the Lunar Society just referred to themselves as men of science. Most were involved in industry or had a position as a physician through which they could gain an income that allowed for them to pursue their passions for science.

The Romantic period was a great time of change for science and was often referred to as the second scientific revolution. In the Philosophical Lectures of 1819, Coleridge is argued to be the first to refer to this period as the second scientific revolution (Holmes *Age of Wonder* xvi). Experimental science was gaining popularity in the Romantic period because it pushed towards a collective and social structure in science. Mitchell writes that experiments within a social context "[regulated] the style of communications between researchers, the mode in which disagreements would be conducted, and the criteria by means of which valid and invalid "witness" of experiments could be distinguished" (7). Pertinent to this discussion is Mitchell's emphasis on regulations and criteria that come into play when science—and experiments—exit the private libraries and studies of the elite and become more social in nature. The social aspect of science became extremely important to the Romantic period. Much of this is explicated in more detail in the previous discussion of the Lunar Society in chapter one. The social push in science not only helped to legitimize the practices of science and those taking part, but it also expanded the nature of what was produced. The social side of science existed in more than just clubs and societies. The growing desire of the public to know and be a part of the changing scientific landscape encouraged the onset of numerous public displays of science.

The provocative and entertaining experiments performed for the public help to characterize the science and scientist of the Romantic Period. Luigi Galvani was traveling the world with his dead frogs showing, or more accurately, demonstrating his theory that there was the source of electricity and life within the body. Scientists were performers.

The attention of the public gained more attention for the scientific community and helped to legitimize work. The performances for the public were not just conducted by quack or pseudo-scientists. Bahar argues that the promotion of science was a way to create a new ideology and Sir Humphry Davy was at the forefront of such promotion through his lectures and demonstrations (41). Sir Humphry Davy, fellow and President of the Royal Society, was a prominent and pioneering scientist in the field of chemistry. Yet, his lectures and performances of his experiments were some of the most popular and highly attended social, not just scientific, events in nineteenth-century Britain. Performances or crazy experiments did not mean that one was not part of the legitimate science community. Thomas Beddoes, a chemist and physician and creator of the Pneumatic Institute, would lock himself in his room exposing himself, and friends, to a multitude of gases to try and record the effects on the body. Even though at one point, his science was written off for its lack of verified theories, he was the first to realize the anesthetic qualities of nitrous oxide. Science began to take a more active role in the public and it was through this that attention to the sciences grew and more money and respect flowed in.

A primary concern of the nineteenth century was the professionalization of science and the scientist. One could grow up to be a scientist, with science considered a field of work rather than just pursue science on the side as many in the Romantic period were forced. Mitchell explains how in the Romantic period, “the proper method, aspirations, and rigor of science had been embodied in the figure of Isaac Newton, and that science required institutions...and the journals these societies used to disseminate the results" (28). This need to follow Newton for 'serious' scientists and the need to have proper institutions to approve, in a sense, what was considered real, not pseudo-science, was present in the Romantic period and only became more detailed and distinct as the century went on. Newton and the inductive method as a part of defining science and the scientist will be discussed in more detail in the following part of the chapter focused on Victorian professionals of science. The idea of a professional scientist was just a budding conception in the Romantic period, and as a result, there were much less defined rules or clear criteria for who a scientist was and what that meant. Even the definition of science itself was malleable and becoming more concrete in the early nineteenth century; "in the nineteenth century 'science' came to signify the study of the natural and physical world. Until that time, it had denoted any sort of knowledge or skill" (Otis xvii). As discussed, in the beginning of the nineteenth century, the intellectual makeup of society was changing and the public was becoming more and more interested in science. And with that, more individuals were attempting to pursue science and this had an important effect in defining the scientist. Otis argues, "Many nineteenth-century scientists were effectively gentlemen scholars...those scientists who did not come from the socially privileged classes had even more to gain by establishing reputations as men of humane learning" (Otis xvii). The changing landscape of science was evident early in the century.

The government provided little funds for laboratories, observatories, or grants to pursue science throughout the Romantic period. Many who did receive funds were considered what David Philip Miller calls "scientific servicemen" (MacDonald 410). Lee MacDonald expands on this through exculpating "the role of the military in securing patronage for, and organizing, science" in the late eighteenth and early nineteenth centuries (410). The Romantic period coincided with the expanding British Empire and one dominating and supported scientific pursuit was that of discovery. Joseph Banks, President of the Royal Society for much of the Romantic period, was known for his dedication to supporting men of science on voyages of discovery and encouraged the surveying of foreign lands for the ultimate benefit of the empire. According to MacDonald, the men of science, the scientific servicemen who "acquired great scientific reputations through military surveys and voyages of discovery [that] became increasingly influential in London scientific circles" throughout the early nineteenth century (410-11). One very popular and evolving discipline of science during the Romantic period was natural history. The practices associated with natural history such as taxonomic classifications or botany were becoming more specialized and formed into their own distinct disciplines. Even biogeography was becoming a specialized field during the Romantic period. Part of the popularity of natural history was due in part to Joseph Banks and the science servicemen just discussed. The explorer, charting the night sky, new lands, and gathering samples of exotic flora and fauna to examine, was very much a part of the makeup of Romantic science and how the scientist was then defined.

Kathleen Turner describes the Romantic traveler as characteristically having a "mysterious compulsion [of the 'unceasing pursuit' which] coexists…in a spirit of enlightened observation" (14). Furthermore, although Enlightenment values shaped the Romantic explorer, unique to the period was the "mysterious compulsion" that kept travelers dangerously committed to their scientific aspirations (Turner 14). Fulford et al furthers this argument when he explains how "the desire [of discovery]…led Britons onwards…in the pursuit of the unknown that lay always just beyond [even though]…the quest might lead to isolation, blindness, and the sacrifice of others" (Fulford et al 104). Additionally, Elizabeth Bohls describes another defining trait of the Romantic scientist's quest as one that "isolates the quester, rending the social ties that stabilize someone" (232). Importantly noted by Bohls is that the isolation does not only cut off social ties from humanity, but more importantly it often cuts off the point of reference that allows for a traveler to stay stable and sane. Bohls emphasizes how quests for discovery are not only dangerous in the physical sense as travelers are venturing to unknown places, but also and potentially more importantly, these journeys are dangerous because of the isolated state they inevitably force the traveler into. Holmes argues that "the idea of the exploratory voyage, often lonely and perilous, is one form or another of a central defining metaphor of Romantic science" (*Age of Wonder* xvi). Dealing with isolation and loneliness was very much part of the job description for a natural scientist in the Romantic period, but the hopes of discovery often outweighed the risk.

Similarly, George Levine expands on this notion with his theory of "dying to know". Levine explains the characteristic of "dying to know": which "implies… a kind of liminal position, at the edge of nonbeing, and it implies a persistent tragedy: only in death can one understand what it meant to be alive" (2). Levine describes how "there is something…that drive it to find things out, even at the risk of life. While obviously we would much prefer not to die; knowledge has been taken to be worth the price" (1). Levine argues that "dying to know" or "the ideal of self-sacrifice or self annihilation" was a significant part of the epistemological development and definition of the nineteenth century scientist (12). And, Holmes argues that these tendencies crystallized conceptions of a scientist that still remain today. For example, he argues that it was Romantic science that reinforced the idea of "the dazzling idea of the solitary scientific 'genius', thirsting and reckless for knowledge, for its own sake and perhaps at any cost" (*Age of Wonder* xvii). These tendencies of self-sacrifice relate closely to the explorers on quests for discovery, but they also apply to other fields of scientific discovery in the Romantic period.

Beyond experimental chemistry and natural history associated with exploration, the vitalism debates were very popular in the early nineteenth century's scientific scene. The pursuit to discover the source or principle of life in connection to the physical human body was central to scientific thought and the burgeoning fields of biological sciences. The great debate focused on the foundation for life: whether it was purely mechanical and material grounded in the workings of the body or that there was a "vital life force"; was life a result of purely physical and material means or was there a supernatural, divine component? As Finn Collin explains, "So long as certain aspects of biological processes were left unexplained in mechanistic and materialist terms, adherents of vitalism would seek refuge in these lacunae, representing them as evidence of the activities of a 'pure vital force'" (286). The debates were controversial because they were not only scientific and in pursuit of truth but ultimately because of their religious implications. If the materialists proved the source of life, it eliminated the power of something more than human to sustain life; it eliminated the divine from the source of life.

One can see the onset of the more drastic and consuming religious scientific debates of the Victorian period, as discussed briefly with the X Club, in the vitalism discussions of the Romantic period. At this point in science, many practitioners were very much still closely tied to theological pursuits, as one of the basic purposes of a natural philosopher was to discover the workings of nature in order to unlock a deeper understanding of the supernatural world. Clearly, this was changing, and the vitalism debate was the central point for the beginning schism between science and the Church. However, not all sciences in the Romantic period were focused on great debates, public displays or epic world journeys. Many of the most significant advancements in science during the Romantic period occurred without stirring up social controversy but rather through long and tedious observations. Astronomy was a popular field of scientific pursuit and one that found support from the government during the Romantic period in part because of all the new discoveries in space. William Herschel, brother of Caroline Herschel, was awarded the Copley medal, elected a fellow of the Royal Society and gained international fame for his discovery of the planet Uranus in 1781 (Hoskin "Herschel, William"). Additionally, he was awarded a pension from the crown and Herschel became one of the most famous and influential professional scientists during the period. Herschel was not traveling the world searching for new peoples and places, nor was he questioning the source of life. However, his popularity rivaled those involved in the more controversial sciences. Astronomy had long been a popular science and the profusion of discoveries during the late eighteenth and nineteenth centuries only contributed to its consistent attention.

Caroline Herschel, Professional Astronomer

Caroline Herschel, unlike many other women of her time and unlike many of the female popularizers (who will be discussed in the following chapter), engaged in scientific research and earned the title of astronomer among her many male counterparts. Nevil Maskelyne, the Astronomer Royal from 1765-1811 referred to her as “Sister Astronomer” in a 1799 letter (Hoskin). Her position as a female astronomer with the respect of significant men in her field was not only unique, but consequential for the future of the field and science as a whole. Additionally, Caroline’s personal journal of observations that she so diligently kept for over 30 years is not just evidence of her career and dedication as an astronomer, but more importantly, “it is one of the earliest records of how science actively gets done, its secret tribulations as well as its public triumphs (Holmes “The Royal Society’s” 4). Her contributions to the field of astronomy and her insight into the day to day job of a professional scientist make her an incredibly important scientist and member of this collective proving instrumental to the future of science and the understanding of the scientist.

Patricia Fara argues that historians, in an attempt to revive attention on certain figures “run the risk of converting yesterday’s women into role models for today by anachronistically giving them modern characteristics” and by “making women from the past into brilliant proto-scientists is just creating a female version of the solitary male genius” (“Portraying Caroline” 123). Yes, this can be the case; however, many women were proto-scientists, or scientists, and acknowledging their brilliance and contribution to science, something so often neglected, despite the limitations and boundaries facing them is important and in no way applies undue praise for their accomplishments. When portraying these women accurately and against the real circumstances of their lives that often included domestic chores and obligations, their accomplishments often rise above those of their male contemporaries because of the ground gained under the astonishing limitations faced. Fara uses Caroline Herschel as an example of a woman never happy and always overshadowed by her brother. Yet, even if Caroline was "immured in domesticity throughout her life" as Fara claims, her accomplishments are greatly important to astronomy and women in the sciences even if she failed to see their importance in her own lifetime ("Portraying Caroline" 124). Caroline's own resentment or disappointment in how her life turned out is unfortunate, but it should not overshadow the way in which her accomplishment paved a future for female scientists. Nor should scholars today feel that they should avoid discussing Caroline and applying praise to her work in fear of "creating a female version of the solitary genius" (Fara "Portraying Caroline" 123). Caroline accomplished much alone as she did in tandem with her brother, and her significant feat in scanning the sky for nebulae and comets is worth discussion centuries later.

Caroline Lucretia Herschel was born on March 16, 1750 and lived in Hanover until she was 22 years of age when she went to England. Unlike many girls in the working class, Caroline was kept at home rather than going into service. Unfortunately, in addition to being kept at home, Caroline's mother Anna did not believe in Caroline being educated in anything that was not necessary to her usefulness around the home (Hoskin "Caroline Herschel's" 443). Caroline yearned to learn more and her father attempted to convince Anna to allow their daughter to take dancing lessons and learn French, but such attempts were futile. Learning French would have made being a governess an option, and Anna did not want to risk her daughter having the possibility of leaving home for work elsewhere. Caroline's mother wished her education be "rough" and "useful" and thus it included teaching Caroline the skills of a seamstress and how to properly handle household chores (Herschel 37). Caroline's education was common for a working class girl, yet it is unexpected given her future successes in the sciences. Although most girls at her time were not provided the same education as men, in more progressive households, girls were often educated in all subjects from mathematics to the classics alongside their brothers. One expects a woman who succeeds in the sciences to have been provided an education. Caroline's lack of formal and informal education speaks to her natural intelligence and ability to grasp materials quickly.

Caroline's lack of education also establishes the argument in the previous chapter that scientists could exist outside the walls of an academy or institution. Caroline not only was not part of an institution supporting science, she was never even formally educated at an academy. Given such a grim and cloistered childhood, it is even more surprising that Caroline achieved such success in her astronomical endeavors. Unlike many of the successful women that ventured into science at the end of the eighteenth century, Caroline was not given the educational background or support to lend to a pursuit of the sciences. Thus, her background underscores the substantial feat of perfecting her observational skills and understanding of mathematics that lead to her discovery of eight comets, numerous nebulae, and a re-cataloguing of the stars in the night sky.

Caroline always desired more than what she was given and her resentment towards her parents for isolating her, stifling her curiosity, and holding her back in the way they did stayed with her throughout her life. In a letter to her niece late in life, Caroline writes, “But as it was my lot to be the Ashenbrothle of my family (being the only girl) I could never find time for improving myself in many things I knew” (Hoskin *Caroline* 109). Hoskin, the editor of Caroline’s writings, notes that Ashenbrothle refers to the character of Cinderella (109). Considering oneself as the Cinderella of the family is a hopeless recognition of one’s low place. And given that Caroline was never married nor ever found any love, she failed to at least experience the relief of a happily ever after like the Cinderella of the fairy tale. One can understand why such resentment followed Caroline throughout her life. Caroline’s father warned her against marriage when she was young. In her autobiography, Caroline recalls her father’s advice, “And I never forgot the caution my dear Father gave me; against all thoughts of marrying and saying as I was neither handsome nor rich, it was not likely that any one would make me an offer, till perhaps when far advanced in life some old man might take me for my good qualities” (Hoskin *Caroline* 47). Caroline, despite an incredibly healthy life, suffered from smallpox at a young age and was forced to bear the disfiguring scars as a reminder throughout her life (Hoskin “Caroline Herschel’s” 443).

Caroline would first be introduced to constellations in the night sky by her brother, William on their journey from Hanover to Bath, England in 1772. This was the start of William's obsession with astronomy, but Caroline was dedicated to forming a career as a singer at this point. Like many who pursued science, initially William earned his salary as a musician and astronomy was simply just a hobby he was developing a great passion for (Hoskin "Caroline Herschel's" 445-47). Once William had proven himself in the astronomical community with the discovery of the planet Uranus, he received the opportunity to move to Datchet, England and take on the role of a salaried astronomer full time. And with William's promotion, Caroline was forced to abandon her budding musical career and move with her brother to Datchet. Caroline had no real option but to follow William's whims once she was in England. He had rescued her from their mother and the drudgery of acting as the household servant, and even though she developed into a talented and respected singer in Bath, ultimately, she felt indebted to her brother. Through singing, she was given the opportunity to provide a life outside of William's home; she was once offered to travel to be part of a performance, but since her brother was not invited, she declined the generous offer; Caroline recognized her role in helping to take care of both their home and William (Hoskin "Caroline Herschel's" 446). Caroline, at one point, found herself feeding William because he was too focused on his work to make the effort, "besides attendance on my Brother when polishing, that by way of keeping him alife, I was even obliged to deed him by putting the Vitals by bits into his mouth" (Lubbock 68). Once in Datchet, Caroline had nothing to pursue on her own, so William provided her with a telescope and entreated her, to her dismay, to spend the nights searching the night sky for numerous objects such as comets, clusters, and nebulae among others (Hoskin "Caroline Herschel as" 374).

Caroline rejected her new role assisting William until she began to recognize nebulae in the night sky. Once her skills improved, and Caroline was able to distinguish features in space, her attitudes towards her new assistantship changed. She used Charles Messier's list of 103 nebulae as a guide in identification and she quickly developed a fondness for observation and discovery (Hoskin "Caroline Herschel as" 376). In February of 1783, Caroline discovered two nebulae not listed in Messier's list and captured William's attention with her skill. Her new discovery proved to him the value of observation at night, as she, a novice, could discover new clusters of stars. And with this rejuvenated view of sweeping the night sky, William began joining his sister nightly (Hoskin "Caroline Herschel as" 376). William produced a new and advanced telescope for Caroline after she had proven to be an asset in her discovery and observation of the night sky. The new telescope had a stronger magnification and was designed to be more efficient for sweeping the sky. Caroline's techniques for observing advanced with her new telescope and she began to chart the varying brightness of the stars in constellations. Her work from 1783 would eventually be published as part of William's work in the last decade of the century that concerned the varying stages of stars based on their brightness (Hoskin "Caroline Herschel as" 382). Despite Caroline's successful observations and discovery of numerous nebulae, William instructed her to assist him in a new endeavor, and thus her personal time searching the night sky for new objects, a task she now thoroughly enjoyed and only when William did not need her assistance in recording his findings, was she able to work on her own search.

In August of 1786, Caroline discovered her first comet and launched herself, as an individual astronomer, into focus. Because Caroline discovered her first comet when William was away on a journey delivering telescopes, she truly earned her place amongst the astronomy elite in England without William. Caroline was cautious when she first observed what she thought appeared "as a star out of focus" and concluded to return to the object the next night to hopefully reinforce her thoughts that this out of focus star was indeed a comet (*Caroline* 89). A week after her discovery, the President of the Royal Society, Joseph Banks, alongside Dr. Charles Blagden, the Secretary of the Royal Society whom Caroline wrote to immediately to inform him of her discovery, knocked on her door and asked her to show them her "comet" (Hoskin "Caroline Herschel as" 384). Caroline's discovery on the first of August in 1786 made her the first woman to be recognized for a comet discovery. Because she was the first woman to discover a comet, she was quick to gain notoriety. This attention went beyond just the scientific circles and even captured the attention of the Royal family (Hoskin "Caroline Herschel: 'the Unquiet" 26). Regardless of Caroline's typical position as assistant to her brother, she was from then on an astronomer in her own right. And it is important to the understanding of science and the position of women that she had been recognized for her work, and reviewed by the President of the Royal Society. This is significant as it legitimizes her position among the professionals of science during the period as well as emphasizes the necessity of peer review in determining new theories and discoveries in science.

Caroline's newly legitimized status as astronomer and her knowledge of the practices of the field makes it understandable, yet still surprising, that she began to receive a 50 pound Royal Pension per year under the title of William's official assistant. This pension essentially categorized Caroline as a professional astronomer, and she became "the first salaried female in the history of astronomy" (Hoskin "Caroline Herschel as" 385). Caroline's skills only improved as time went on, even if she struggled at times to discover anything worthwhile. Two years after her first comet discovery, Caroline proved it was not a fluke and she observed her second comet on December 19, 1788. The discovery of this comet was not only significant as a new comet, but the Astronomer Royal, Nevil Maskelyne, took notice of her exquisite work as he claims, "As it [the comet] came up from the South it seems that Miss Herschel lost no time in finding it, I mean that it could not have been seen much sooner even in her excellent telescope" (Qtd in Hoskin "Caroline Herschel as" 386). Praise from the Astronomer Royal for Caroline's skill is significant in demonstrating her unique role as a respected female scientist.

Caroline took her work quite seriously and was meticulous in noting her observations of the night sky; however, she was equally if not more dedicated in her role as William's scribe when he worked on the twenty-foot telescope. The French geologist Barthelemy Faujas de Saint-Fonde visited the Herschel's observatory one evening while they worked. Faujas de Saint-Fonde describes his experience as a witness to their work,

> I arrived at Mr Herschell's about ten o'clock...I observed, in a window at the farther end of the room, a young lady seated at a table, which was surrounded with several lights' she had a large book open before her, a pen in her hand, and directed her attention alternately to the hands of a

> pendulum-clock, and the index of another instrument placed beside her, the use of which I did not know: she afterwards noted down her observations. I approached softly on tiptoe, that I might not disturb a labour, which seemed to engage all the attention of her who was engaged in it; and, having got close behind her without being observed, I found that the book she consulted was the Astronomical Atlas of Flamsteed, and that, after looking at the indexes of both the instruments, she marked, upon a large manuscript chart, points which appeared to me to indicate stars. (Qtd in Ridpath 17)

Caroline was not just an amateur at home using a borrowed telescope admiring the heavens. She demonstrated a knowledge of the night sky, and, more importantly, of the technology available in her field and through learned skill, she was able to observe and record her findings in the most scientific fashion. Her dedication to the field of astronomy is shown in her consistent observations even when they felt endlessly fruitless. In 1791, Caroline writes, “I have kept no memorandum of my sweepings, tho’ I believe I may say that I have neglected no opportunities whenever they offered; but, not meeting in any comet, I looked upon keeping memorandum of my disappointments as time thrown away” (Qtd in Hoskin “Caroline” 385-386). Even throughout droughts of discovery, between the seventh of January 1790 and seventeenth of April 1790, Caroline would discover her third and fourth comets through which she garnered not only the attention of the scientific community, but the general public. A cartoon depicting Caroline as the female astronomer was published only a few weeks after her fourth discovery.

Caroline’s importance to the field was not lost even when she had nothing of importance to record. After a visit from Maskelyne in 1793, he wrote of Caroline’s perfected methods for sweeping the night sky to Nathaniel Pigott. Writing to Pigott is significant as Pigott was a fellow of the Royal Society, inducted for his achievements in astronomy. Maskelyne wrote after detailing her methods, “Thus you see, wherever she sweeps in fine weather, nothing can escape her” (Qtd in Hoskin *Discoverers* 139). Caroline’s discoveries were significant in their own right, but what is even more fascinating in understanding her role as astronomer, is how her observations and notes were used by many, even Maskelyne, in attempts to better understand the movement of objects in the sky, especially comets. Caroline was not simply observing objects, the measurements taken during her observations were valuable additions to the field and provided useful information that other astronomers could use and learn from.

Beyond observing and sweeping the night sky for new objects, Caroline made additional contributions to the field of Astronomy. William had noticed errors in John Flamsteed's British Catalogue of Stars from 1712 (first pirated edition) and thus encouraged Caroline to revise the catalogue by compiling a new corpus of all the stars in the sky (Jardine 4). Caroline did more than just correct errors in Flamsteed's original, she realized over 500 stars were missing and brought the total of catalogued stars from 3000 to over 3500 (Ridpath 17). Maskelyne found a more universal use for the new catalogue than Caroline had originally planned. She was correcting errors to help support William in his own work, yet the Astronomer Royal thought all interested in observing the night sky should have the benefit of such a thorough and complete catalogue and so he commissioned the Royal Society to publish Caroline’s compilation of stars in book form (Hoskin “Caroline Herschel’s” 456).

Caroline stayed in England until the death of William, at which point she returned to Hanover. Due to the nature of the town and the lack of a high enough workspace, Caroline’s astronomical work declined to nonexistent while in Hanover. William’s eldest son, John, wanted to continue his father’s work. However, John had an active role in the scientific communities in England including the Royal Society, and thus he claimed to have no time to research and locate the necessary information in the sky to transition his father’s catalogue of nebulae to make it useful to the common observer. Caroline, respecting John’s attempt to continue William’s work, was charged with assisting him by locating “reference stars and arrange them in a format suitable for sweeping…[then] she had to replace the reference stars with the actual nebulae” (Hoskin “Caroline Herschel’s” 460). This task would take Caroline two years and upon completion in 1825, her work would be recognized for its great contribution to the field. And ultimately, in 1828, she was awarded the Gold Medal from the Astronomical Society for her final work (Hoskin *Discoverers* 194). Late in life, Caroline had not fully turned away from her work even if her home did not provide suitable workspace. She wrote out instructions for people to follow if they desired to sweep the sky for objects. She had perfected the science herself, and felt it necessary to share her methods for observation with others, so they too could do it effectively. (Hoskin “Caroline Herschel as” 390).

Scholar and Herschel historian, Hoskin, argues for Caroline’s impactful role in the astronomical community of her time. He writes,

> Caroline was an indispensable member of a most remarkable team that, in one of the greatest campaigns known to observations of astronomy, swept the whole of the visible sky. In twenty years of unremitting toil, brother and sister increased the number of known nebulae from about a hundred to 2500. (Hoskin “Herschel, William” 3)

Even Agnes Clerke, Victorian female popularizer who is spoken in detail about in chapter three, wrote a biography of the Herschels in 1895 detailing their role in the development of the field of astronomy during the late eighteenth and early nineteenth centuries titled, *The Herschels and Modern Astronomy.* Clerke writes,

> Caroline Herschel was the first woman to discover a comet; and her remarkable success in what Miss Burney called "her eccentric vocation" procured for her an European reputation...She held her comets, not withstanding, very dear. All the documents relating to them were found after her death neatly assorted in a packet labeled "Bills and Receipts of my Comets"; and the telescopes with which they had been observed ranked among the chief treasures of her old age. (124-25)

Caroline's individual role was more than just assistant as she was responsible and credited for numerous nebulae discoveries. Her legitimate role as a member of the practicing science community laid the groundwork for many women to follow. And it also changes the definition of the scientist. Caroline shows that women could make capable scientists. Just as many in the century argued that one need not be Oxford or Cambridge educated or from the aristocracy to pursue science, Caroline demonstrates that one not need be a man. Caroline pushes against previous limitations established in the sciences first and foremost through her sex but also through her lower class and uneducated upbringing.

Caroline's passionate dedication to her and her brother's work was unending. She garnered the attention of many and even after her move back to Hanover, she would be entertained with visits of the scientific elite including geologist Gregory von Humboldt among others. This significant praise and attention was not awarded to all and speaks to Caroline's vast and exceptional contribution to a popular scientific field in the nineteenth century. Caroline was popular and respected by her fellow men of science, even beyond the field of astronomy. After publishing her correction to the catalogue of stars, Caroline was invited to spend a week as a guest of the Astronomer Royal at the Royal Observatory in Greenwich. Additionally, the inventor of the kaleidoscope and respected physicist and mathematician Sir David Brewster referred to Caroline's last work (the reorganization and catalogue of the nebulae discovered by her and William) "an extraordinary monument of the unextinguished ardour of a lady of seventy-five in the cause of abstract science" (QTD in Hoskin "Herschel, Caroline" 4). Caroline's life is evidence of the significant dedication that people of science undertook in order to discover or rather uncover knowledge that others could benefit from. Caroline's initial drive in astronomy was selfless as she aimed to help contribute to her brother's work. Yet through this, she entered into a space in science of her own, earning the respect of the most esteemed men in her field.

Caroline, after the discovery of her first comet, wrote out a detailed account of the circumstance around her discovery and her findings. This account was sent to Dr. Charles Blagden, the secretary of the Royal Society, who then would visit alongside Joseph Banks, to determine the validity of Caroline's findings. After substantiating Caroline's claims of a new comet, her letter was read at a meeting of the Royal Society in 1787. Not only was Caroline the first woman to discover a comet, or the first professional female astronomer, Caroline was the first woman to have a paper read at a meeting of the Royal Society—the preeminent organization for scientific research and advancement in Britain, and arguably, the world. Although brief, the letter is important in how she explains her scientific methods used to observe and confirm her discovery.

Caroline, like one would expect of a scientist, provides the details for her observations, which shows that she recognized the importance of being thorough and descriptive when explaining a new astronomical finding. Caroline presents the circumstance around her discovery; she says, "I have taken the opportunity of his absence [William was away] to sweep in the neighborhood of the sun, in search of comets" (Herschel 3). Caroline describes the timeline for her discovery in the letter as well. This is of great importance for two reasons: one, Caroline understands that timing is specific to how one can determine whether or not an object in the sky is a comet. The other reason is because Caroline does not notify Blagden through the letter until the second of August, the night after she first located the comet in the night sky. Caroline did not wait for superficial reasons to notify Blagden; she explains that due to a haziness that developed in the night sky on the first evening of the discovery, she wanted to reconfirm her finding the following evening in order to "intirely satisfy myself as to its motion (3). Caroline was diligent and concerned with the accuracy of her finding. Based on her observations on the first night, Caroline theorized that she had in fact discovered a comet—that which she had been seeking because the "object very much resembling in colour and brightness the 27th nebulae of *Connoissance des Temps* with the difference however of being round" (Herschel 3). Caroline's close knowledge of the nebulae in the sky allowed for her to recognize the difference in the object that she discovered from the nebula that it closely resembled. However, the slight doubt that it was not a comet, one that arose due to the change in weather before she could compile enough evidence to trace the comet's motion, kept Caroline from reaching out to Blagden on the first night. As any scientist would, Caroline desired the evidence to prove her theory before introducing it to the community. On August 2nd, the following night, she achieved the measurements, through observation, needed to solidify her claim that she did in fact discover a new comet.

In addition to providing the basic circumstances of her discovery to Blagden, Caroline also included in the letter her detailed observation notes and drawings of her findings. Caroline understood the ways of the scientific community and knew that she needed more than a claim to present enough evidence to garner the attention of the astronomical men she was reaching out to. For example, Caroline writes that at the end of the first night of observation, "By the naked eye, the comet is between the 54th and 53rd Ursae Majoris, and the 14th, 15th, and 16th Comae Berenices, and makes an obtuse triangle with them, the vertex of which is turned towards the South" (3-4). Her figures point out the comet's location between two stars. She would then use these documented location notes from the first night to compare to the comet's location on the second night in order to track its movement. The movement of the object in relation to the stars would be the evidence Caroline needed to prove her discovery of the comet. In her observational notes from night two, Caroline writes, at "10h. 9', the comet is now, with respect to the stars a and b, situated as in fig. 4 therefore the motion since last night is evident" (4). Caroline provides one more observation for night two and then describes the mechanism through which she was able to observe the comet and make this new discovery. The description of her telescope as "a Newtonian sweeper of 27 inches focal length, and a power of about 20" is critical. In documenting scientific evidence of a new discovery, Caroline recognized the need to not only describe her circumstances in making the discovery, but also the need to provide the detailed observation notes and equipment used in order to give enough scientific evidence for substantiation of her claim.

The reader would not need to rely on her word, as she provided the scientific evidence to prove her theory. Caroline completes the letter requesting that Blagden share her findings with her "brother's astronomical friends" (4). Caroline had discovered a new comet in the night sky before but was unable to relate her findings to someone important enough in the field to substantiate it in a fast enough manner, and so another astronomer beat her to the credit. She did not want to risk that again so she rode into the night in order to deliver the letter. Blagden accepted and followed through on her request to share her findings. After her discovery proved accurate through verification, Blagden presented her account to the Royal Society. The diligence taken by Caroline in a concern for accuracy proves that Caroline was more than a mere lucky observer. She demonstrates the actions of a person of science—she, through her dedication to her work, helps to define the expectations for a scientist.

Caroline, similar to so many working in pursuit of scientific knowledge, lived a solitary and sad life in her late years despite her fame and numerous substantial contributions to the field. Even with the incredible achievements of Caroline in the field of astronomy and for women in the sciences, she looked back on her life in her old age as nothing but a series of disappointments; she calls her life, "a laborious life of a succession of disappointments" (*Caroline* 34). One gains a sense that others, too, recognized her suffering late in life. At her death, her niece, who had been taking care of her, wrote, "I felt almost a joyful sense of relief at the death of my aunt, in the thought that now the unquiet heart was at rest" (Herschel *Memoir* 346). Caroline, like so many who pursued nature to unlock new, yet to be discovered, knowledge, had something within her that could not be satisfied regardless of the amount of discoveries or successful inventions. This insatiable desire, or rather inability to be content with one's achieved knowledge or contribution to science and the world became a driving characteristic associated with the perception of the scientist.

The end of the Romantic period of science was ushered in with the deaths of three notable men of science; Sir Joseph Banks, William Herschel, and Sir Humphry Davy, all died within the ten years before 1830 (Holmes *Age of Wonder* 435). These scientific pioneers helped to shape and define the landscape of Romantic science, Banks heralded in the era of exploration and discovery, while Herschel represented the great advancements made in the field of astronomy, and Davy was the face of chemistry. They represented the three main fields that defined Romantic science. But with the start of the 1830's, scientific pursuit was moving forward, and it was a time that signaled a need for change. As science grew in new fields, a need for professionalization was evident. Charles Babbage published *Reflections on the Decline of Science in England* in 1830 where he derides the state of science in Britain for its lackadaisical approaches and lack of real funding for distinguished researchers and men of science. Additionally, Babbage argues for a need to transition the state of the societies in Britain to one that mirrored a more European model where he claimed the best science was occurring at the time. In the "Preface" Babbage acknowledges that he might ultimately offend some, but his goal, or rather hope in creating the text, was "that it will ultimately do some service to science" (1). Babbage wanted a more professional field where peer review was required for papers and the membership of the society actually consisted of men producing work in the sciences discussing science rather than a social club (Holmes *Age of Wonder* 437-40). Ultimately, he called for changes that he felt would allow Britain to reclaim its place on the pedestal of scientific knowledge that it once held. Babbage was not alone in his frustrations with the scientific community in the 1830's. John Herschel, son of William Herschel, and nephew to Caroline, was very active in the scientific community at this time, but he also shared the concerns that Babbage held.

Instead of writing a document that could offend many in his community, Herschel took a different approach to share his desires for a changing field and presented his *A Preliminary Discourse on the Study of Natural Philosophy* in 1831. In addition to desiring a changed and more professionalized scientific landscape, Herschel also sought to open the public perception of science to be one not of fear, but of respect. In order to reach a point of respect and public approval, Herschel, in the introduction, addresses the distrust or objection to science from a religious standpoint,

> Nothing, then, can be more unfounded than the objection which has been taken, *in limine*, by persons, well meaning perhaps, certainly narrow minded, against the study of natural philosophy and indeed against all science...The character of the true philosopher is to hope all things not impossible, and to believe all things not unreasonable. (6-8)

Herschel is attempting to show that science is not necessarily in constant opposition to religion. Yet, he continues on to acknowledge the necessity of searching for the truth, without bias, for all, not just scientists. He writes,

> Nevertheless, it were much to be wished that such persons, excellent and estimable as they for the most part are, before they throw the weight of their applause or discredit into the scale of scientific opinion on such grounds, would reflect, first, that the credit and respectability of *any* evidence may be destroyed by tampering with its honesty; and, secondly, that this very disposition of mind implies a lurking mistrust in its own principles, since the grand and indeed only character of truth is its capability of enduring the test of universal experience, and coming unchanged out of every possible form of *fair* discussion. (9-10)

Here, Herschel is attempting to show that science and religion can coexist as long as all involve acknowledge what is true, and with that what it means to be considered truth. Herschel not only is appealing to a better reception and understanding for scientific pursuit here, but he is also acknowledging the need for scientists to be honest and unbiased in the research they attempt.

Herschel discusses numerous scientific disciplines in his inquiry, but rather than arguing how they are completely separate, he shows that there are unifying factors between all fields of science. Richard Holmes describes Herschel's three-part inductive method that he connects to all branches of science, "First, the precise gathering of quantitative data by observation and experiment; second, the emergence of a general 'hypothesis" from this data; and third, the testing of this hypothesis once more by experiment and observation, to see if it could be disproved (Holmes *Age of Wonder* 441). By presenting an inductive method that was central to all practicing in the fields of science, Herschel was creating a more general population of professionals of science, and one that was expansive. Even though Herschel spoke to unique disciplines and classifications within science (which would become quite definitive in the later part of the century), he was also calling for all to be considered under the umbrella of science. Now, this does not appear to be so unique or even original, but as part of his work, it helps establish a new understanding of those who pursued scientific research; "This notion of a great network or connection of sciences, beginning to form a single philosophy and culture, was crucial to his [Herschel's] book...John Herschel sought to give 'the man of science' a new and central place in English society--and not just the Royal Society" (Holmes *Age of Wonder* 445). Herschel and Babbage's desire, among many others at the time, for a new professionalized and authoritative science would define the period of Victorian science. This notion is not unique, as discussed in the first chapter that explained how it was the goal of the members of the X Club, the establishment of so many societies as authoritative in the unique fields of science in the Victorian period was one way to provide a voice to more professionals of science in the public sphere.

Victorian Professionals of Science

For Victorian culture, science was not pushed to the outside or completely separated from the everyday. The culture was embedded with scientific thought and curiosity as one can see the seeds of in the Romantic period. This was especially true for those in London who regularly had access to new pieces of discovery in museums, on display in the Crystal Palace that was built for the The Great Exhibition in 1851 or through public lectures and presentations (Davies 13). For example, Michael Faraday, a prominent English scientist, delivered numerous lectures in multiple societies such as the City Philosophical Society and the Society of Arts for the general public. He was active in helping to incorporate science into the mainstream and thus helping to legitimize and stabilize the role of the scientist in everyday society (Frank). But science infiltrated more than just public curiosity through lectures. Politicians regularly had science and the role of science on their mind, as scientists involved themselves in politics fighting for authority and educational reform. The debates between the legitimacy of science as an authoritative body versus the church were some of the most heated political discussions of the period. De Young describes how Victorian society was familiarized "with the idea that a scientist was someone who could explain the natural world and, from his vantage-point of knowledge, guide the policies of society" (217). Victorian scientists were fighting for an authoritative voice that involved more than just discussing new experiments; they wanted a voice in more pressing social concerns, especially in the changing face of education for a growing middle class and literate community.

A primary concern during the period was determining what constituted science and who was a professional of science—a scientist. A common pastime or vacation activity for Victorians would be to collect their own specimens of flora and fauna as they traveled the world or simply walked in the fields surrounding their homes. As Bernard Lightman writes, "Victorians of every rank, at many sites, in many ways, defined knowledge, ordered nature, and practiced science" (*Victorian Science* 1). What then defined a professional of science or a scientist when science was so interwoven into Victorian life? This very question is one that many attempted to answer and define during the period. As discussed in the first chapter, one of the primary roles of the X Club and its members was to separate and professionalize science and the scientist outside of casual participation in a scientific act, such as a person collecting species on a trip. A scientist was more than just a person who casually conducted collection or participated in an experiment. Laura Otis explains how "at the 1833 meeting of the British Association, William Whewell proposed the term 'scientist' for investigators who had until then been known as natural philosophers" (xvii). But we know that many fought throughout the period to legitimize science as a profession and field that carried with it great authority on the working of the natural world.

Daily life in Britain was changing rapidly. The technological and societal advancements associated with the industrial revolution and the growing middle class, and thus the changing nature of the British economy, in addition to the spreading of the British empire throughout the world, had great influence on all aspects of life and industry, including science. Many scientific advancements in the period were made out of questions and problems that arose within different industries. For example, Bruce Hunt argues that the growth of the British cable industry inevitably affected British work in electrical science (322). The growing cable network posed new problems and scenarios for scientists and engineers to work through. In solving the issues associated with the cable industry, new instruments created such as a mirror galvanometer, siphon recorder, voltmeters, ammeters and electrometers were first part of or derived from needs in the cable industry and then quickly became commonplace in physics laboratories throughout Great Britain (Hunt 323-24). This is just one example of the way that industry influenced science and how in turn, science responded. However, in the previous chapter's discussion of the Lunar Society, much of the scientific discussions and thus discoveries of the members were a result of questions that arose out of a business need of one of the members. This tendency only expanded and grew throughout the early century into the Victorian period. The task of defining Victorian science is too great to take on in this chapter, let along this project as a whole. To do that justice, as many have attempted, one must venture to consider the myriad of influences on science ranging from class to gender, from industry to empire, from rights and race to religion. However, what this chapter will do then is aim to bring light to the ideas and the points that started to define what it meant to be a practitioner of science and how professionals of science during the Victorian period were part of the greater science network that together was responsible for shaping the cultural perception of science and the scientist.

With the professionalization of the scientist, there also came expectations of what constituted a scientist and his responsibilities in his scientific endeavors. Newton and his contemporaries' dedication to the inductive method, "the branch of reasoning concerned with ascending from particulars to general principles," was highly influential on the methods and modes of Victorian scientists (Bellon 222). Richard Bellon argues, "For the Victorian men of science, the scientific revolution of the seventeenth-century natural philosophers...revealed what was possible when men disciplined their imagination and renounced their vanity with patience, humility, and courage" (222). A necessity for

Victorian scientists was the testing of theories—one must submit his work tirelessly to testing, and regardless of personal motivations and desires, the results were final. John Tyndall, a member of the X Club and prominent Victorian physicist, argued at the Royal Institution in 1854 that "If a man be not capable of this self-renunciation—this loyal surrender of himself to Nature, he lacks, in my opinion, the first mark of a true philosopher" (190-91). The scientist's or the investigator's ability to remain unbiased in his pursuit for the truth, as evidenced by submitting one's work to vigorous testing regardless of desired results, was significant to earning the respect and approval of the public for scientific gains. The moral notion associated with the inductive method and pursuit of natural truth is part of how the Victorian scientist earned his authority and position within society. Bellon explains, "The natural philosopher earned his liberty, Whewell explained, through a diligent and self denying approach to investigation" (223). Tyndall and Whewell are just two examples of Victorian scientists who recognized that in order for men to continue their scientific pursuits, they needed the freedom granted to one with authority, and that was earned through the moral pursuits underscored by the inductive method.

An emphasis is placed on the *moral* pursuits of men of science and the necessity that such investigations and research were, in fact, moral. The ripening debate between the clergy and the Church and scientists who found no need for the Church to step in while dealing with questions of truth was central to understanding the methods developed as standard while pursuing scientific investigations during the period. Because the discord between science and the Church permeated most discussions of science by some factor during the Victorian period, finding a way to navigate the discourse surrounding science so to still find a way to be effective without losing all support was important. Many men of science used the inductive method as a way to further establish their authority and garner support in their scientific pursuits. The inductive approach to scientific investigation "did not encourage impiety" and according to Herschel

> true science and true religion worked together to deflect human nature from 'a direction which terminates in the wildest vagaries of mysticism and clairvoyance.' With this reassurance, men should be prepared to accept science in 'the wisdom of her views, the purity of her objects and the faithfulness of her disciples.' (Bellon, Herschel Qtd in Bellon 232)

By connecting the goals of religion and science—to discover the truth, and by not presenting the two in opposition of each other, Herschel helps to establish a place for science that garners authority and allows for support. By describing the inductive method as a way to produce a moral investigation to science, regardless of where one stood within the debate between science and religion, one could continue to practice without being rejected by the religious public.

The inductive method emphasized rigorous testing and the need to remove personal motivation from the results process. Similar to the inductive method, Peter Galison argues, "In the nineteenth century…the desired character of the natural philosopher inverted to one of self abnegation" (Qtd in Levine 3). John Herschel, in his *Preliminary Discourse,* which was discussed briefly for its call for a unified and professional science, argues for the importance of being selfless and therefore virtuous in the pursuit of the natural sciences. Additionally, Michael Faraday praised Herschel for influencing him in a way that not only benefitted his observation and research skills as a scientist, but more significantly, Herschel's text made him "a better philosopher" (Faraday Qtd in Bellon 227). The importance of the scientist removing his own personal attachment and objectives continued and became more concrete throughout the Victorian era. George Levine explicates this in *Dying to Know* when he expounds how "Galison points out that for the nineteenth century scientists, the responsibility to be "objective", to gain access to objects of knowledge and thus to allow the facts to speak for themselves took priority over the fullness of understanding" (3). Objectivity formulated the most significant requirement of what was expected of a scientist. One needed to be objective in order to be fully capable of experimenting and receiving accurate results about the workings of nature. Christopher Herbert in *Victorian Relativity* confirms this ideal when he writes, "a corresponding insistence on a rigidly puritanical code of objectivity [was] the prerequisite of achieving 'truth to nature' in scientific representations" (1). Part of the expected objectivity also included a complete detachment from the experiment and results of the experiment. Levine argues that "detachment…gives science its authority" and that "disinterest and objectivity" were conditions "necessary for adequate scientific observation and experiment" (246, 249). Lorraine Daston in "The Moral Economy of Science" claims that the meticulous and anti-individual tendencies of the "fearless observer" scientist that defined the nineteenth century were adapted in order to attempt to universalize scientific findings making them available to all communities (22). The goal of the scientist was to conduct as objective of an experiment as possible, meaning he was to remove any of his own personal feelings, aspirations, or concerns from the realm of his science and rather conduct the experiment in order to reveal the secrets of nature.

For respect and consideration as a professional scientist during the time, one had to follow a set of standards. Levine describes the ideal scientist of the Victorian era as one who “watches from a distance, and the accuracy of her vision is a consequence of her forced detachment” (64). However, this forced detachment that was required of the scientist also had an austere affect on how the public viewed scientists. The forced detachment and required objectivity, De Young argues, “played into the vision of scientists as thinking machines devoid of normal human feeling” (210). Levine furthers this argument by claiming “science acquired that cold and aloof reputation that places it at the remotest distance from the affairs of the human heart” (19). And as Daston explains, this self control and detachment was necessary in order to withhold the standards for a scientific experiment that could enlighten all (22). Although these descriptions of the scientist have a somewhat isolating, distancing effect, the detachment and objectivity necessary for experimentation allowed for the scientist to occupy a place within society that was not held to the same moral and ethical standards as the lay community.

Porter claims the “special authority” granted to science and, thus scientists, arises from “disinterested disengagement” and “scientific objectivity” (320). The special authority came with “a willingness to repress the aspiring, desiring, emotion-ridden self and everything merely personal, contingent, historical, material that might get in the way of acquiring knowledge” (Levine 2). Any aspect of the scientist’s own feelings regarding the experiment or the impending results of the experiment needed to be suppressed, even at the risk of breaking moral or social codes. Small and Tate emphasize this point in

Literature, Science, Psychoanalysis when they describe how a scientist would have the "determination to go on asking questions of the world, and letting its logic be tested through her, no matter how obstructive the responses she receives" (3). True knowledge and scientific gain would only stem from experiments that were completely detached from all concerns of the scientist—the ideal state of detached scientific objectivity. This harkens back to Herschel's encouragement for a science that sought truth, whatever that truth may be. Only through detachment can a scientist discover more reliable scientific results.

The importance of the ultimate goal and end result of science allowed for the blurring of typical ethical and moral lines. Levine claims "since the point of the argument [scientific experiment or pursuit] ultimately is the advancement of science for the betterment of humanity, it was less likely to cause problems on a larger scale" (255). In 1865, Claude Bernard, a renowned physiologist wrote that "a man of science [is] absorbed by the scientific idea which he pursues" and thus is devoid of any hesitation or sense of moral responsibility in the pursuit of a larger goal (207). Bernard in his *Introduction to the Study of Experimental Medicine* argues that "No hesitation is possible; the science of life can be established only through experiment…it is essentially moral to make experiments… even though painful and dangerous to him, if they be useful to man" (206). A Victorian scientist was fulfilling his duties and operating within the expectations of the field of science as long he was pursuing a larger goal objectively and detached from potential results.

Levine asserts how "the 'scientific' investigator will not shrink from the effort and will not back off from the results if they turn out not to satisfy emotional needs. This would seem to require not only intellectual but moral strength" (19). Levine is arguing then that although the scientist was able to bend societal standards of what was moral or ethical in the pursuit of science, the scientist still maintained a high level of "intellectual and moral strength". Furthermore, Levine contends, "Darwinian science had transformed humans from those investigating to those investigated" (245). Levine signals the progression of Darwinian theory presented in *On the Origin of Species* to Darwin's later publication which applies his evolutionary theory to human kind: *The Descent of Man.* The moral pursuit was not hindered by the change in the focus of science. Amanda Anderson in *The Powers of Distance* explains detachment and objectivity during the nineteenth century as an attempt at practices with the "progressive potential" to "objectify facets of human existence so as to better understand, criticize, and at times transform them" (6). Anderson defends the attempts at detachment and objectivity in the form of science and the scientist during the nineteenth century as it was an attempt to elucidate facets of life for the betterment of the whole. Additionally, Anderson, while discussing Daston, explains how objectivity and the anti-individual actions were in fact moral since the purpose of the method was to end with results that could be universally beneficial (11).

Not all Victorian scientists were concerned with questions of morality, but the necessity of objectivity and detachment were important regardless. As discussed before, the beginning of this need was stimulated with Newton and the inductive method. If one was not personally concerned with the outcome, or trying to find a specific answer, if one could remain unbiased, then he was in the moral clear in his scientific pursuits. Evolution and the changing biological sciences were the most popular for scientific discussion and debate during the Victorian period. As the vitalist debates had dominated the Romantic era, evolution, thanks to Darwin, dominated the Victorian period. Also similar to the vitalist debates, the science of evolution brought with it many religious questions. Darwin, aware of the potential for discord, and in an attempt to not let religious issue cover the purpose, very carefully allows for God within his theory of evolution. But even with that, evolutionary theory was a highly volatile topic for debate within the scientific and greater Victorian community.

Vocal members of the scientific community, especially those who dedicated much of their time to popularizing science in an attempt to establish it as a secular authoritative voice for society outside of the Church, such as the members of the X Club, found much to grab onto in evolutionary theory. For many Victorian scientists, religion or theology played no role in their actions. And that was okay because to be morally right in science meant removing one's own bias, it had nothing to do with religion. James Clerk Maxwell was a Christian scientist during the Victorian period, yet he rarely, if ever, took part in the larger popular debates. In his papers, Maxwell argues for his theory of science,

> it is not by discoveries only, and the registration of them by learned societies, that science is advanced. The true seat of science is not in the volume of Transactions, but in the living mind, and the advancement of science consists in the direction of men's minds into a scientific channel; whether this is done by the announcement of a discovery, the assertion of a paradox, the invention of a scientific phrase, or the exposition of a system of doctrine. It is for the historian of science to determine the magnitude and direction of the impulse communicated by either of these

> means to human thought. But what we require at any given epoch for the advancement of science is not merely to set men thinking, but to produce a concentration of thought in that field of science which at that particular season ought to be cultivated. ("The Scientific Papers" 401)

This helps show a reason for why some professionals of science stayed out of the more political nature of science. It was the role of the historian, according to Maxwell, to communicate what the advancement means to people and the role of the scientist "to produce a concentration of thought in that field of science which at that particular season ought to be cultivated" (Maxwell 401). The religious debate within science in Victorian culture could easily dominate the discussion of what it means to be a scientist and in highlighting individual scientists; however, I have made a purposeful decision to select a scientist outside of the evolutionary debate of the nineteenth century for closer analysis. For one, everyone knows Darwin and is familiar to some extent, great or small, with Darwin's theories. Additionally, it is important to bring attention back to the physical sciences where great advancements and achievements were accomplished during the nineteenth century that have very real effects in daily life today.

James Clerk Maxwell, Victorian Physicist and Mathematician

Maxwell's scientific and mathematical pursuits and accomplishments were extensive and varied ranging from color optics and color science to electromagnetics, thermodynamics, kinetics, and even molecular work associated with understanding the rings of Saturn. According to CA Coulson, "there was scarcely a subject Maxwell looked at, and he looked at many, that his insight did not change out of recognition" (Reid, Wang, Thompson 1651). The esteemed nature of the comments made about Maxwell by his contemporaries on his expertise and excellence as a physicist speak to his contribution to science in the nineteenth century. His tutor, William Hopkins, shared with a friend that, "It appears impossible for Maxwell to think incorrectly on physical subjects" (Qtd in Reid, Wang, Thompson 1651). Today, even with his lack of popularity outside of physics or the fact that many do not know who James Clerk Maxwell is or why he was so important, every scholar who writes about him refers to him directly, in so many words, as great. William Cooper calls Maxwell "the greatest theorist of the nineteenth century" (136). These sentiments appear universal from contemporaries of Maxwell's to Einstein to physics and history of science scholars today.

James Clerk Maxwell was born in Scotland in 1831. As an only child and after the passing of his mother at age 8, Maxwell received incredible attention and support from his father. His father, John Clerk Maxwell, has numerous interests outside of his profession as a lawyer including in the sciences and technical advancements. There is no doubt that his own interests were influential on Maxwell's future scientific pursuits. Maxwell's father would bring him in his youth to the meetings of The Royal Society of Edinburgh and The Royal Scottish Society for the Arts, which influenced Maxwell's later works (Harmon 1). In addition to the great and varied education that Maxwell received through exposure by his father, he, too, received an extensive formal education beginning at age ten at the Edinburgh Academy. Maxwell met Peter Guthrie Tait at the Academy, a year his senior, and developed a close and lasting friendship. Tait, also a mathematician and physicist, is best known for his work in energy physics and his joint compilation with

William Thompson, *Treatise on Natural Philosophy,* which attempted to establish North Briton as the hub for energy conservation science (Smith "Tait" 1). Tait and Maxwell, both excelling students, were regularly in competition for the Edinburgh Academical Club prize and through their academic time together, "a culture of gentlemanly competition characterized the close friendship...until the latter's death" (Smith "Tait" 1). Tait was Maxwell's closest scientific correspondent and friend, and it would be Tait who would write his eulogy after his early death. The competition between the two men pushed Maxwell to keep learning and working on his mathematical knowledge. While at the Academy, Maxwell wrote his first scientific paper when he was just fourteen. Maxwell's paper covered his exploration of how to produce curves using a two-pin and string system. His father, always his strong supporter, was impressed with his son's work and showed his paper to a professor friend. This professor, James Forbes, was quite floored with Maxwell's paper as it simplified the process for curves that Descartes had constructed (Forbes and Mahon 133). Forbes presented Maxwell's paper to the Royal Society of Edinburgh officially ushering in the start of Maxwell's scientific career.

Following the Academy, under the guidance and mentorship of Forbes, Maxwell started his university education at Edinburgh University, but he shortly transferred to Trinity College at Cambridge where he completed his education on a mathematical track (Reid, Wang, Thompson 1654). While studying at Trinity College, Maxwell would take courses in "mechanics, and the theory of gravitation, as well as geometrical and physical optics, including study of the wave theory of light" (Harmon 2). These courses would set the path for Maxwell's interests and scientific pursuits throughout his long and productive career. While at university, Maxwell participated in the Adam's Prize competition that was focused on the study of "the motions of Saturn's Rings" for 1857. The subject of the prize was announced two years prior, and Maxwell quickly began work (Harman 4). Maxwell received the Adam's prize for his essay "in which he concluded that the rings must consist of masses of matter not mutually coherent—a conclusion that was corroborated more than 100 years later by the first Voyager space probe to reach Saturn" (Rogers 201). Tait, a childhood friend of Maxwell's and fellow scientist, refers to his theory on Saturn's rings as one of "Maxwell's greatest works" (335). Following a fellowship at Cambridge, Maxwell's first professional appointment was at Marischal College (Marischal College would merge with neighboring King's College to form University of Aberdeen) in Aberdeen, Scotland as a professor of natural philosophy in 1856.

The years of 1860-1865 were some of the most productive years for Maxwell. He published his first two papers on the electromagnetic field, which were highly influenced by the work of Faraday thirty years prior. Additionally, during this time, Maxwell continued working in color science and developed the equipment necessary to produce color photography. As a result, in 1861, "Maxwell created the image of the tartan ribbon...by photographing it three times through red, blue, and yellow filters, then recombining the images into one color composite" ("First Color Photograph"). In 1861, President George Stokes invited Maxwell to give the Bakerian Lecture for the Royal Society, but because Maxwell was not yet a fellow of the Society, he had to refuse his first invitation. His lack of membership was quickly righted with an invitation by Stokes a year later (Harmon). In 1866, Maxwell finally presented the Bakerian Lecture for the Royal Society. His lecture, "On The Viscosity or Internal Friction of Air and Other Gasses" was based on work he had started much earlier in his career while he was still a professor at Marischal College before he moved on to an appointment at King's College in London (Reid, Wang, Thompson 1657). Maxwell struggled as a teacher because he found it difficult to stick to his script and often went off on tangents that were above the comprehension of most of his students. He would at least allow his students to copy his written lectures, which were clear. But as one of his students, astronomer David Gill wrote of him, "and to many it seemed that Clerk Maxwell was not a very good professor. But to those who could catch a few of the sparks that flashed as he thought aloud at the blackboard in lecture, or when he twinkled with wit and suggestion in after lecture conversation, Maxwell was supreme as an inspiration" (Qtd in Cropper 159). Maxwell was always available for his students even if his lectures failed to be the most helpful.

Also during this time, Maxwell became involved with the cable industry that his colleague, William Thompson was highly involved in. Thompson testified that more science and experimentation was needed to make the underwater cables proficient after the failure of the Atlantic and Red Sea cables (Hunt 324). A committee was formed in 1861 and Maxwell "supervised the experimental determination of electrical units for the British Association for the Advancement of Science, and this work in measurement and standardization led to the establishment of the National Physical Laboratory" (Rogers 200). Outside of the experimental work that Maxwell conducted and supervised, his work with electromagnetic theory also had close ties with the cable industry and his theories had direct implications in the work that was being done. After Maxwell's death, prominent cable engineer, Oliver Heaviside would publish applications of Maxwell's theory for cable technology in the trade journal *Electrician* under the title "Maxwell's Equations" (Hunt 328). The necessity of scientific advancement that resulted from insufficiencies in the cable industry led to a great space for Maxwell's science to flourish.

In 1865, Maxwell left his position in London at King's College and returned to his family estate, Glenlair, in Scotland. He left King's College in part because he did not need an institution to support and facilitate his work; he had the funds independently and was, at that point, well established in the scientific community. But more so, Maxwell wanted to be back at the estate to enjoy the natural surrounding it offered. "What he really wanted was more time at Glenlair "to stroll in the fields and fraternize with the young frogs and old water rats"" (Cropper 159). While in Scotland, Maxwell focused on turning his research on the electromagnetic fields into more formal writings, which ultimately produced his 1873 *Treatise on Electricity and Magnetism* (Rogers 200). In addition to his work on electromagnetic theory, throughout Maxwell's time at Glenlair, he published over 17 papers on his research, including his *Theory of Heat*. Maxwell's *Theory of Heat* is crucial in its role in helping to understand science and the scientist in the nineteenth century because it emphasizes the keen importance of the imagination in Maxwell's work.

In *Theory of Heat,* for lack of a better way to describe his theory, Maxwell invents a creature as way to explain a phenomenon. William Thompson, a colleague of Maxwell's, would refer to this creature as a demon and it became known from that point forward as Maxwell's Demon (Forbes and Mahon 220). More significant than what Maxwell theorized about heat, is how he did it. Maxwell published what some consider the first thought experiment as a tool for discussing and understanding scientific theories. Even at a time when science was becoming more professionalized and disciplined into numerous divisions, the imagination was still an important tool for scientists. Some tend to think of science as devoid of imagination, but as shown by Maxwell, it could be incredibly useful for theoretical experiments. Future scientists in physics would adapt the thought experiment as a useful way to develop theories. J. Richard Gott explains how Einstein proves that "universal times does not exist" through a thought experiment: "Einstein proved the idea by using a clever thought experiment: he imagined constructing a simple clock by letting a light beam bounce back and forth between two mirrors" (44). Numerous scholars explain in detail how thought experiments formed the basis for much of Einstein's theoretical work. Additionally, Einstein once said "the special theory of relativity owes its origins to Maxwell's equations of the electromagnetic field" (Qtd in "Who Was James Clerk Maxwell"). Maxwell's use of thought experiment would form the basis for Einstein's own theoretical work substantiating the role of the imagination while conducting scientific research.

For Maxwell, his imagination and the ability to set up analogies and get creative when he lacked understanding or the precise knowledge to make a claim was the tool that lead him to greatest discovery. His imagination and use of analogy provided the structure to keep his thinking progressing rather than falling short and stopping progress altogether. Maxwell knew the analogies were imaginative and not based in truth, "I do not think it contains even a shadow of true theory" (Qtd in Cropper 154). Yet, as Cropper notes, "in each he intuitively recognized elements of truth, which he built into his evolving theory. In the end, he took away the mechanical models, like the removal of a scaffolding, and what was left were mathematical statements, the now-celebrated "Maxwell's equations" (154-55). Maxwell's tendency to use his imagination and analogy in his scientific work was influenced by one of his mentors during his brief time at Edinburgh University. William Hamilton was a philosopher and taught Maxwell that, "knowledge is not absolute but relative to, and shaped by, the limitations of the human senses; to get at truth, imperfect logical devices such as models and analogies are necessary" (Cropper 157). Hamilton's influence is seen throughout Maxwell's work; nowhere is his influence more prevalent than in the *Theory of Heat* with Maxwell's demon.

Physics was a quickly developing and changing field during the mid-nineteenth century. Even though Maxwell had technically given up his professorship at King's College, he would travel every spring to help in administering exams in mathematics, and it was this time in London that kept him visible at the college and within the scientific community (Rogers 200). Because of the rapid development of experimental physics, the Chancellor of the college felt there was a need to establish a new position and in 1871, Maxwell became the first Professor of Experimental Physics (Harmon 11). Part of the funding for the position included funds to develop and build a laboratory. Maxwell was involved from the start helping with design and the acquisition of instruments needed to make the facility state of the art. The Cavendish Laboratory first opened its doors in the spring of 1874 and Maxwell would remain there until his death in 1879. Throughout his tenure as the Professor of Experimental Physics, Maxwell had a significant impact in establishing the laboratory as prestigious and successful and helped to bring Cambridge back to a place as a leader at the forefront of experimental physics work (Forbes 231-35).

Maxwell's approach to physics and his way to understand the natural world was revolutionary for his time and in his field. "It was he who began to think that the objects and forces that we see and feel may be merely our limited perception of an underlying reality which is inaccessible to our sense but may be described mathematically" (Mahon 176). Much of Maxwell's work was comprised of theories that would not officially be verified until long after his death. But in his short time, his curiosity and imaginative approach to the natural world helped redefine the way that many approached physics. Einstein claims that "one scientific epoch ended and another began with James Clerk Maxwell" (Belendez). Maxwell's influence and accomplishments were great to evoke strong praise from one of the most renowned physicists of all time. Yet, in his lifetime, many did not provide him with the recognition or praise that he deserved. For example, even though Maxwell's electromagnetic theory was proven true by experiments conducted by Heinrich Hertz in 1886 through which he provided the verification through experimentation needed for the scientific community to consider the work valid; at the time and even after, many of his contemporaries considered Maxwell's work fanciful and were incapable of understanding his projections and theories. According to Maxwell scholar Basil Mahon, one reason for his lack of acclaim during his life is because his work and theories were too forward thinking (177). The scientific community around

Maxwell could not quite comprehend his science and therefore it was approached with some distrust. Because of Maxwell's process, much of which rested in the abstract, not only was there a lack of attention but as Cropper argues, to his colleagues, much of his findings and equations "seemed like the conjuring trick of a magician. One colleague remarked that Maxwell's world of electromagnetic theory seemed like an enchanted fairyland" (155). Additionally, Maxwell was a very humble man and did not go around promoting his work in the scientific community or public sphere like many scientists of his time.

When some scientists such as Darwin had men like Huxley promoting and popularizing their work, it is no surprise that they became household names and that Maxwell did not (Mahon). Maxwell was not concerned with speedy production and publication of theories. He was not interested in fame or popularity. As such, much of his greatest works progressed over decades. He explained his long process to a friend once, "I believe there is a department of mind conducted independent of consciousness, where things are fermented and decocted, so that when they are run off they come clear" (Qtd in Cropper 155). Maxwell was more focused on accuracy and actually gaining an understanding of how the world worked around him rather than gaining acclaim. Ultimately then, he allowed his mind to work and process ideas regardless of the time it took or if his colleagues or the scientific community understood his greatness or not. One cannot help but wonder what was left fermenting in his mind when he died at only 48.

Maxwell, for as prodigious he was in his scientific writings, was also a skilled poet and would often take his science and questions he had and transform them into verse. Tait argues for his talent and praises his verse when he writes, "...it always had an object, and often veiled the keenest satire under an air of charming innocence and *naive* admiration. No living man has shown a greater power of condensing the whole substance of a question into a few clear and compact sentences than Maxwell exhibits in his verses" (337-38). One of his most recognized poems *To the Chief Musician upon Nabla,* he refers to as a Tyndallic Ode. He was making a direct reference to the physicist John Tyndall. What is most surprising about his poetry, and this ode in particular, is that it is written in iambic pentameter with well-crafted stanzas, exhibiting prosody, alliteration, and many other poetic tropes. Maxwell did more than just write poetry, he did it well.

For the limited life he had, Maxwell died at age 48, his scientific contributions to mathematics, physics, color science, among so many other fields were vast. He let his work do the talking for him. Maxwell's electromagnetic theory "is now an established law of nature, one of the central pillars of the universe. It opened the way to the two greatest triumphs of twentieth century physics, relativity and quantum theory, and survived both of those violent revolutions in tact" (Mahon 2). Yet so many outside of people working in physics today are ignorant to his lasting contributions to science and, especially, to daily life today. Maxwell took the first color photograph and helped to distinguish, with Young's work, the three-color model used in televisions. Many know the name Edison or Bell for their inventions and discoveries, but Maxwell failed to become a household name. Victorian Britain was a place of great change for the sciences in the nineteenth century, yet with change came immeasurable discovery and Maxwell among many other practitioners of science in the Victorian period such as Darwin, Faraday, and Kelvin set the foundation for much of what science has come to understand and define today.

Maxwell, like many other scientists of his time, was focused on his work more than being a public and political face for science during the period. He was not in the X Club, nor did he regularly surrounded himself with the popular and celebrity men of science; however, his contribution to the science network as a practitioner of science—a scientist—was immense. History often focuses on those who were written about the most or most often in the headlines, and as a result it tends to neglect the role of the quiet men and women diligently working to uncover the mechanisms of nature for the benefit of others. These scientists deserve more clear and focused recognition for their work and great contributions and James Clerk Maxwell was one of them.

At the age of 48, what was once just usual heartburn developed into unbearable pain for Maxwell. Because of the unrelenting and increasing nature of his pain, "Maxwell suspected that he had contracted the same type of abdominal cancer that had killed his mother at the same age" (Forbes and Mahon 237). Within a few months, Maxwell would succumb to his illness while seeking care from a pain specialist, Dr. Paget, at Cambridge. In a description of his time spent with Maxwell, Dr. Paget wrote, "As he had been in health, so was he in sickness and in the face of death. The calmness of his mind was never one disturbed" (Qtd in Campbell and Garnett 318). Dr. Paget describes a calm and intelligent man, and even in the face of death remained true to his character. Dr. Paget finishes his description of Maxwell by saying, "no man ever met death more consciously or more calmly" (Qtd in Campbell and Garnett). Maxwell was always a quiet and humble man who focused on his work and contribution to the future of his field. But he was also a kind and generous man who regularly gave of his time to help students and friends and few ever spoke negatively of his character. Many were very taken by his untimely and sudden decline and death. Forbes and Mahon argue that Maxwell's style of writing reflected his nature and amiable personality; "perhaps more than any other scientist's, his personality comes over in his work: he seems to elicit a unique blend of wonder and affection" (240). His curious spirit was evident at a young age and the youthful desire to know and understand the world around him never perished. A 1925 *Times Educational Summit* claimed, "To scientists, Maxwell is easily the most magical figure of the 19th century" (Qtd in Forbes and Mahon 240). This spirit of Maxwell's attracted many around him and his loss was profound.

Maxwell's loss was especially felt by his lifelong friend, Tait. Tait was tasked with writing his obituary, which he would present at the proceedings of the Royal Society of Edinburgh, and would later publish in the journal *Nature.* It seems appropriate that Maxwell's first official debut into the world of science would also be the place where his final life accomplishments would be recounted. In the obituary, Tait gives a detailed account of Maxwell's youth and career including descriptions of many of his most important theories and findings. The end of the obituary becomes much more personal for Tait and is evidence that he was grieving a great loss. Tait writes,

> I cannot adequately express in words the extent of the loss which his early death has inflicted not merely on his personal friends, on this Society, on the University of Cambridge, on the whole scientific world, but also, and most especially, on the cause of common sense, of true science, and of religion itself, in these days of much babbling, pseudo-science, and materialism. But men of his stamp never live in vain, and in one sense at

> least they cannot die. The spirit of Clerk-Maxwell lives with us in his imperishable writings, and will speak to the next generation by the lips of those who have caught inspiration from his teachings and example. (338-39)

Tait was not wrong, Maxwell's contribution to science was grand and his role in current science is still relevant.

Maxwell's demon is one of the most important contributions Maxwell made to nineteenth century science and physics that is still impactful today. Not only was this a very popular and significant work of Maxwell's but it also highlights his imagination and the creative nature of his thinking in order to account for aspects of the theory he could not otherwise describe. The final chapter of Maxwell's book, *Theory of Heat,* "Molecular Theory of the Constitution of Bodies" is where his demon comes to life. The subsection of the chapter, which is the second to last in the book, is titled "Limitation of the Second Law of Thermodynamics."

Maxwell begins the section by reiterating from earlier in his text the second law of thermodynamics. Briefly, Maxwell describes that the second law defines the impossibility of an inequality of temperature or pressure without the expenditure of work within a closed system that does not permit change in volume or the passage of heat (308). He then states that this established fact in thermodynamics is "undoubtedly true as long as we can deal with bodies only in mass and have no power of perceiving or handling the separate molecules of which they are made up" (308). At this point, the reader begins to understand why this exception, or limitation to the law is being discussed this late in the text and not earlier on when Maxwell first introduced the law. His final chapter is on the molecular theory of bodies, and his proposed limitation to the law only exists at the molecular level. Maxwell states, “as long as we can deal with bodies only in mass” then the second law holds up (308). The moment one wants to investigate bodies at a molecular level then the second law no longer holds true. Because there was no way to actually see bodies at the molecular level during his time, Maxwell must try and perceive how this would happen and it is that very reason that he begins his thought experiment.

Maxwell relies on the imagination of his audience to think along with him in order to understand his rather important claim that the second law of thermodynamics is in fact not absolute truth, but limited in certain ways. Maxwell writes, “But if we conceive a being whose faculties are so sharpened that he can follow every molecule in its course, such a being, whose attributes are still as essentially finite as our own, would be able to do what is at present impossible to us” (308). Maxwell just conceived of his demon. As one can see so far Maxwell only referred to his conception as a ‘being’ and had actually thought of referring to the being as a ‘valve’ (308). However, his colleague beat him to the naming and as soon as William Thompson referred to it as the demon, there was no going back.

Maxwell recognizes that he is asking a lot from his readers to follow in his imaginative experiment; right after introducing this being with sharpened faculties, he brings the reader back to something concrete and understood. Maxwell says, “For we have seen that molecules in a vessel full of air at uniform temperature are moving with velocities by no means uniform, though the mean velocity of any great number of them, arbitrarily selected, is almost exactly uniform” (308). Closely analyzing Maxwell’s language is beneficial before we discuss the science at the center of Maxwell’s claim. He is not just presenting a theory and leaving the reader out of the science. As he did with the start of the thought experiment, he again here explains how “we” are looking at something together. “We” are conceiving of a being. Maxwell invites his readers to join with him and conceive of their own beings with sharp faculties who can discern the individual molecules of bodies. Maxwell shows a level of care and encouragement for his reader as he invites them to join with him to participate in the experiment. He wants the reader to imagine this scenario so they too can then understand his proposed limitation to the law. If he was not concerned with how his audience comprehended his material, he would have used very different language.

At this point, Maxwell has established the need for a being who can discern individual molecules but has not explained why. He reminds his audience that molecules in a sort of vessel move at different individual velocities with no uniformity, even if when one looks at a group together, they appear uniform. Maxwell reminds his readers of the random movements with different velocities because it becomes essential to his explanation of why looking at individual molecules presents an exception to the law. Maxwell moves on to the details of the thought experiment and the role of the being. “Now let us suppose,” again, Maxwell uses inclusive language so the reader feels like he is on this adventure of imaginative experimentation with Maxwell,

> that such a vessel is divided into two portions, A and B, by a division in which there is a small hole, and that a being, who can see the individual molecules, opens and closes this hole, so as to allow only the swifter molecules to pass from A to B, and only the slower ones to pass from B to A. (308)

Basically, the being is in charge of operating an opening where it allows the fast molecules to enter into chamber B and the slower molecules then can only pass through the hole into chamber A. This, then, would result in a chamber A that is full of slow molecules and a chamber B full of fast molecules.

Maxwell concludes the thought experiment with the results and consequences of such an occurrence. Maxwell explains how the being "will thus, without expenditure of work, raise the temperature of chamber B and lower that of A, in contradiction to the second law of thermodynamics" (309). The second law requires work to be expended in order for temperature or pressure to change, and this imagined experiment, with Maxwell's being at the helm, just proved that it may not be impossible at the molecular level for temperature to change without work. Maxwell takes this experiment's result to argue for a statistical rather than dynamical methodological approach to calculation in order to receive more accurate results. Maxwell claims that this example is only one of many circumstances "in which conclusions which we have drawn from our experience of bodies consisting of an immense number of molecules may be found not to be applicable to the more delicate observations and experiments" (309). Making calculations from the statistical method is important for Maxwell because the "strict" nature of the dynamical method requires "we follow every motion by the calculus" and that is just not compatible with many investigations (309).

Maxwell argues that the statistical method for calculations in experiments that investigate ideas about nature is necessary because "our actual knowledge of concrete things...is of an essentially statistical nature, because no one has yet discovered any practical method tracing the path of a molecule or identifying it at different times" (309). Maxwell's science is clear and straightforward even though it relies on the power of one to imagine a being who can identify molecules. He is keen to interject throughout his thought experiment moments of concrete science to reassure the reader's confidence. Additionally, the language Maxwell uses is clear and inclusive. He invites the reader to join him in his laboratory for an investigation into the laws of thermodynamics. His use of personal pronouns such as "we", "us", and "our" keeps the reader engaged as an active participant in the thought experiment. He regularly reminds the reader of what they know and helps reassure their foundation and basis for the experiment and pending results.

Maxwell invites his reader into the world of thermodynamics and presents his findings in a clear and approachable way. His work was brilliant and his ability to understand physics was uncontested. He was confident in his theories and a humble man who felt no need to grandstand or make his work unintelligible to the average reader in order to prove some level of elite scientific knowledge. Maxwell was unique for this and his scientific papers would make a guide to many in the sciences today. If all scientists wrote with such eloquence and clarity, many more in society would be exposed to and more knowledgeable in attempts to understand the natural world around them.

If all scientists had written more like James Clerk Maxwell, the writers of popular works on science for the general non-scientific public would have been in much less demand. Yet, based on the numerous popularizers of the sciences in the nineteenth century, we know this not to be the case. But Maxwell provides a writing style for the sciences that is worth emulating. When we look back on Victorian Science, the popularity of Darwin and the debates surrounding new evolutionary theories dominate the scientific purview. However, James Clerk Maxwell, whose work Einstein referred to as "the most profound and the most fruitful that physics has experienced since the time of Newton" and his contributions to the physical sciences deserve similar recognition or at the very least, remembrance, in the vast contributions to science made in the Victorian period (Domb).

Almost 150 years after the death of Maxwell, his scientific theories are not obsolete and actually still provide inspiration and the foundation for current technological advancement. For example, in "Underwater Digital Holography for the Study of Marine Plankton," Sun describes how Maxwell's equations for holography are the basis for the current work that developed the eHoloCam, an underwater holography video recorder (Sun). Maxwell's work had applications that were influential in his own lifetime, but essential in considering his lasting influence is recognizing his contributions to the nineteenth century science network and his definitive role of a scientist. Additionally, recognizing his continued influence on scientific advancement today shows that a study in nineteenth century science is not just beneficial for its historical illuminations. As seen through Maxwell, looking to the science of the past can have positive impacts on current scientific development.

THREE

The Collective of Female Popularizers of Science in Nineteenth Century Britain: Jane Haldimand Marcet and Agnes Mary Clerke

Growing literacy rates in the eighteenth century created a new population of society that could read and therefore develop interests in numerous topics previously excluded from them. Science was among the growing fields of interest by the new literate public. “For England...an expansion of literacy rates for the middling ranks had occurred by the end of the seventeenth century” (Houston 4). Included in the growing rates of literacy were children. Female children were often trained in different subjects than the male students as to prepare them for their different spheres in adulthood. Nevertheless, children were being educated and literacy rates were growing. In addition to children, female literacy rates grew rapidly, even more quickly than male rates, by the middle of the eighteenth century. Women readers became a dominant audience for publishers and many publications were developed with a female audience in mind. In addition to a drastic increase in book publication, estimates put 200 million copies of books printed in the 1500s and 1500 million copies printed in the 1700s, other forms of literature grew rapidly such as the monthly or weekly journals (Houston 5). The rise in education and literacy led to discussions about what information women should be learning in order to most properly serve as the head of the domestic sphere. Some men argued that “women’s education should prepare them for marriages where they submit to the dictums of their more knowledgeable and rational husbands” (Bahar 37). While others argued against this more traditional view for female education and favored instead one that provided "the habit of industry and attention, the love of knowledge, and the power of reasoning" to women (Edgeworth 20-1). An expanded print culture and body of literate consumers "brought knowledge about science and medicine to a largely non-specialist, though predominantly middle-class, public" (Jordanova 24). The expanded print culture and greater literate public, in addition to the growing push for female education provided publishers a demand as it made necessary new publications aimed directly at a juvenile and female audience that covered topics such as religion, philosophy, politics, and most importantly for this discussion—science.

This new genre of science literature designed for educating both children and women was established in the mid 1700s (*Victorian Popularizers* Lightman 20). John Newberry published *The Newtonian System of Philosophy, adapted to the capacities of young gentlemen and ladies* in 1766, while Benjamin Martin's *The General Magazine of Arts and Sciences* started a series titled "The Young Gentleman and Lady's Philosophy" (Lightman *Victorian Popularizers 20*, Gates and Shteir 6). Martin's articles "were designed to familiarize readers with recent developments in astronomy, optics, and hydraulics" (Gates and Shteir 6). The new genre of publications also created a place where the female writer could find authority. Since it was the woman's role to run the household and educate the young in moral and religious matters, women were accepted as writers with authority on these topics. Eliza Haywood published a magazine specifically designed for women titled *The Female Spectator* in 1744. The magazine focused on providing an aid to "improve the morals and manners of its age through essays, stories, letters from putative correspondents, and editorial replies designed to enlarge the horizons of its female readers" (Gates and Shteir 6). Among the topics for discussion in the *Spectator* were activities in science that women could participate in.

The field of women's publications and women writers was not without controversy, however, as there was still the constant debate about the role of women in society and how this new instruction and education would affect that. Many of the initially popular female writers such as Haywood and Charlotte Lennox made it clear to their publishers that the goal was not to create professional women in these fields of instruction but rather "to render the ladies though learned not pedantic, *conversable rather than scientific*" (Lennox Qtd in Gates and Shteir 7). Texts for women were consciously aimed at improving a woman for her future role in the home without providing too much education or information that could distract a woman from her role. As subjugating as this sounds to a 21st century audience, which it was, it surprisingly backfired in a way by providing a whole new realm for women to find a central place of authority in society. Gates and Shteir argue that "as women across the middle ranks of society were directed toward home, family, education, and the general culture of piety and improvement, education of the young took on enlarged cultural value, and educational writings became an arena that women could claim for themselves" (7). Women, now, had a key role in developing the instructional tools for other women to use in not only educating children, but in turn, educating themselves.

This new arena for women would dominate the instructional and introductory science writings of the late eighteenth and nineteenth centuries. Thus garnering an incredibly influential role for women in science during the period. In discussing the female role in the history of chemistry, Meyer argues,

> Women are often hidden in the history of science, but historically they have played a major role in bringing science to a broader audience. In the early 19th century, when boundaries between physics and chemistry were still in flux, writing for a general audience--choosing what to include, what to exclude--also meant defining chemistry as a discipline. ("The Chemical" 64)

This influence on the development of chemistry that Meyer claims for women can also be seen amongst many different scientific pursuits at the time. Science was in a time of flux and change in the late eighteenth and early nineteenth century and the majority of science that society, or the main literate public, was exposed to was being presented to them by women. Women were writing the introductory and instructional texts on chemistry, mathematics, physics, astronomy, botany and others. Women were translating the scientific theories of the men of science for a reading public when traditionally such theories were, only available to an elite few who understood the elevated technical scientific language. Women selected the theories, experiments and information to include. Thus, as Meyer argues about chemistry, it is impossible to deny the significant role that women held in the development of science during this time.

Female popularizers of science are an important collective in the science network for their role in disseminating knowledge. Even if some attempt is made to argue that popularizers are not individual original creators in science, they are still active members of the science community whether one wants to acknowledge it or not. The authority granted to science by society in the nineteenth century was not due to science being created and consumed in a vacuum of other men of science. The first two chapters have produced evidence for the social, political, and in turn, public nature of science. In this sense, female popularizers of science are equally important to science and the scientist as are the professional practitioners. Neeley adds to this argument by claiming that "intermediaries" or popularizers "are essential for the functioning of the scientific community" (208). But I argue they do more than just add to the functioning of the community, they provide a space for the scientific community within the larger community of general society. The female popularizers introduce science to the general public and therefore create the need for a role of the formal members—the professionals of science—to fill. Without the female popularizers in the nineteenth century, the popularity of science would not have flourished and therefore science would not have had the possibility to rise and claim authority over matters of the world and nature. Scientists would not have been able to take such authority from the church if the society did not recognize the importance of science—and they did so in much part because of the popularizers. The exposure to scientific theories that came with the writings of the female popularizers was essential in providing people with the opportunity to learn and then potentially invest in and cultivate a more advanced understanding of scientific fields that could then contribute to new discoveries and innovations in science. The female popularizers may have been relegated by the men in science and society to writing introductory books for children and women on scientific theories, but their work reached a far greater audience and had incredible influence on the future of science through mere exposure.

Female writers of science focused on in this chapter will be referred to as "popularizers" of science. As many scholars before have noted, the term "popularizer" is one of questionable connotation. There is a potential confluence of meaning with the word popularizer between what is considered a popular science writer and a writer who popularizes science. The term, then, is "laden with negative and ideologically weighted connotations" (Gates and Shteir 1). However, as many have argued before me, this chapter while acknowledging the potential negative connotation, moves past it and uses popularizer to represent a group of individuals who worked to bring science to the public. Particularly for this study, these individuals were women, therefore they are to be referred to as "female popularizers" of science.

Romantic Female Popularizers of Science

The popularizers recognized their ultimate goal in writing works on science and it was that they needed to produce works that people would want to read and could understand and find engaging. Not only did the style of letter or conversation work because it was deemed more feminine, but also because readers found it more interesting. Knight explains, "The style of the letter, the conversation, the catechism, or the lecture appealed to those popularizing science and afraid that the neophyte might be put off for life by too dry a style" (136). If the purpose of writing an introductory text to science was to expose a new audience, then it only makes sense to choose a format that is comfortable and approachable for the reader as the material itself will already have been quite foreign.

Thinking in these terms, the popularizers made a strategic move by writing in the form of letters or dialogue and were genius in creating a genre style that was both comfortable and engaging while also informative on topics that were typically considered difficult to grasp. The more comfortable readers were, the more they would choose to engage with these new subjects. Thus, the popularizers understood their audience well enough to truly make science popular to a new part of society.

Most historians speak of Margaret Cavendish (1623-1673) and her role as a female writer of science in the seventeenth century. Cavendish was the first woman to attend a meeting of the Royal Society and later relayed her criticisms and commentary on the men of the Royal Society in her "Observations on Experimental Philosophy." Cavendish is probably most widely recognized for her work *Blazing World* (1666), which many consider the first ever text of science fiction (Holmes "The Royal Society's"). One early nineteenth century popularizer of science was Margaret Bryan (17?-1815). Bryan's most notable publication was her text, *A Compendious System of Astronomy* produced in 1797. Bryan ran a small school for girls and would use her work as teaching resources. Like most female science writers of this time, Bryan was not an active member in the scientific community and had no real connection to the scientific establishment. She followed along with what was typical and deemed appropriate for women writers by producing her text particularly for a young female audience (Lightman 63).

The most productive and noteworthy early nineteenth century female popularizer of science was Jane Marcet. Her first and most prodigious publication was *Conversations on Chemistry* in 1806 when she was 37 years old. She published vigorously throughout the rest of her life producing numerous volumes on different topics while always going back and revising and adding to her first works to bring them up-to-date. Altogether, Marcet published six major texts including *Conversations on Political Economy* (1816), *Conversations on Natural Philosophy* (1819), *Conversations on Vegetable Physiology* (1829), *John Hopkins's Notions on Political Economy* (1833), and *Mary's Grammar* (1835). Marcet, like many female writers who produced texts for women and children, used familiar conversations and characters to instruct her readers on the topics of her volumes. However, Marcet was praised for her ability to comprehend and understand the topics and relay them with steadfast accuracy.

Jane Haldimand Marcet - A Romantic Female Popularizer of Science

Jane Haldimand Marcet was born to a wealthy banking and merchant family in London, England in 1769. Her family believed in education and fostering intellectual growth and Jane was an active participant. She was educated alongside her brothers and continued to pursue her learning independently as an avid reader in both French and English (Morse 1). Marcet's father was Swiss and hired tutors who followed the traditional Swiss educational format that included instruction in chemistry, biology, history, Latin, art, music, and dancing (Rosenfeld 788). Her widespread educational instruction in her youth no doubt provided a solid foundation for her future achievements. After the death of her mother when Marcet was just 15, she took over the household responsibility (Morse 1). This new responsibility included playing hostess for her father's numerous dinner parties that regularly entertained 40 or more guests comprised of "scientists, writers, intellectually, important visitors to London and other stimulating people" (Rosenfeld 788). Marcet had a strong relationship with her father that led to him living with her even after her marriage to Alexander Marcet when she was 30 years old. Alexander Marcet was a trained physician interested in the sciences, particularly in chemistry. He enjoyed the regular dinner parties put on by Marcet's father and so they continued after the marriage with some new invitees from Alexander. Through these parties, Marcet was introduced to famed experimental chemist Sir Humphry Davy, botanist Augustin de Candolle, mathematician Horace Benedict de Saussure, and even political philosopher Thomas Malthus (Rosenfeld 788-89). The discussions that Marcet was exposed to through years of hosting the dinner parties could only have added to her curiosity and interest in contemporary philosophy and scientific innovation.

Beyond just entertaining the intelligentsia in London, Marcet had a real interest in chemistry and science. She regularly would participate in conversations with her husband and his colleagues and readily asked questions if she did not understand the topic at hand. She was eager to continue widening her level of knowledge on the topics. As Meyer writes, "Marcet's lack of a formal scientific education did not restrict her, as it would have later in the century. Much science talk happened around dinner tables, where women were eager participants" ("The Chemical" 64). Due to her interest in chemistry and the social role of attending lectures, Marcet would attend the entertaining lectures of Humphry Davy at the Royal Society. This was fashionable for the social elite at the time, but it was more than that for Marcet. She would have long conversations with her husband after the lectures to clarify Davy's experiments and the theories in chemistry that he was demonstrating. One of Davy's lectures, and her subsequent confusion and desire for clarification led to her most popular publication.

Unlike the reasoning many men gave for women to be knowledgeable in the sciences, Marcet does not just expose women so they can be active participants in conversation with their husbands; she saw the importance for women to understand chemistry, among other sciences, so they could understand the natural world and the changing industrial world around them. In the first chapter "General Principles of Chemistry" in Marcet's *Conversations on Chemistry,* Mrs. B, the tutor who teaches chemistry to Caroline and Emily, is explaining the history of the field. Through this, Marcet argues for the significance of chemistry to people in the current age. Mrs. B says, "The modern chemists...by their innumerable inventions and discoveries, they have so greatly stimulated industry and facilitated labour, as prodigiously to increase the luxuries as well as the necessaries of life" (Marcet 27). Marcet sees a role for science in the mind of a woman beyond just preparing her for domestic life. Creating more opportunities for women to understand the world around them was a primary goal for Marcet and can be seen in the numerous topics that she chooses to write on.

Some contemporaries of Marcet were frustrated in her methods as she regularly made clear that she was just relaying the knowledge of others and not the original generator of ideas, while also establishing that she was writing for the female sex--essentially, she was criticized by other female writers because she too easily kept to the space that she was granted as a woman. Myers argues that "through the fiction, Marcet defines a forum in which she can take on chemistry while still remaining on terrain granted to women of her class" (57). The frustrated statements of her contemporaries are clearly understandable, what one can see today, though, is how Marcet was able to cover so much more ground for women in the fields by not overtly causing disruption with her male counterparts in science. She wrote for women, but more than just women read her work and her level of production was incredible. She brought chemistry, botany, and natural philosophy to women and the general public in a way that it had never been provided before. Her ability to clearly relay theories that were quite convoluted to a general audience heightened the level of knowledge and intellectual capacity for so many. Her ability to stimulate the mind of the reader and encourage curiosity in women, children and the working class was no small feat.

Whether she overtly pioneered new positions for women in the sciences or not does not matter. Even in "keeping to her place" she did create space for a future of women and middle class individuals in the sciences because she exposed them to science at unprecedented levels. One can see how she does this in *Conversations on Chemistry* by looking closely at how she introduces theories and principles in the conversations between Mrs. B and Emily and Caroline. For example, when discussing the principles of light and heat, she introduces the work of scientists Sheele and Herschel to discuss the separation of light from heat through an examination of refrangibility. After an explanation of their experiments and findings, Emily asks, "Though I no longer doubt that light and heat can be separated, Dr. Herschel's experiment does not appear to me to afford sufficient proof that they are essentially different; for light may like-wise be divided into the different coloured rays" (Marcet 29). Marcet creates conversations with pupils that do not just agree or understand every property that their teacher describes. Through the questioning, Marcet allows for a more thorough and detailed discussion of the property being described. Mrs. B responds to Emily's question—she says,

> No doubt there must be some dissimilarity in the various coloured rays. Even their chemical properties are different. The blue rays, for instance, have the greatest effect in separating oxygen from bodies, as was found by Scheele; and there exist also, as Doctor Wollaston has shown, rays more refrangible than the blue, which produce the same chemical effect, and, what is very remarkable, are invisible. (40)

The response given to Emily not only addresses her question but provides even more information on the property with specific reference to the scientists who discovered and experimented with the principles. This provides the reader with more than just an explanation as it also gives them a gateway to explore the theory from its source, if they were so inclined.

What is most unique and important in the way Marcet presented the chemical theories in the text is her staunch adherence to accuracy through only discussing that which could be supported with evidence. Emily responds to Mrs. B's discussion by asking, "Do you think it possible that heat may be merely a modification of light?" and Mrs B. responds, "That is a supposition which, in the present state of natural philosophy, can neither be positively affirmed or denied. Let us therefore, instead of discussing doubtful points, be contented with examining what you can understand respecting chemical effects of light" (40). There are numerous places throughout the text that rather than conjecturing, Marcet brings the focus of the discussion back to what is known and understood. There are occasions, too, where she will discuss recent results from an experiment but is sure to qualify them if she does not feel that the evidence is substantial. For example, in a discussion of the transformation of gases to liquid, she mentions the experiment by Perkins but claims, “he has not told us what method he employed to obtain this enormous pressure, so that experiment has not been verified” (192). These examples show us not only how clearly she presents information on chemistry for a novice audience, but also and more importantly, how seriously she takes her work. She proves that it is important, no matter who your audience, to present accurate and clear information while also teaching about the nature of science and experimentation and the need for verification to provide evidence for new propositions in the field. She is training her readers to be science-minded and to think like a scientist—not just to be able to mention a topic in conversation. While training her readers to think like scientists, she also then is explaining what it means to be a scientist

This style opens the door of science, chemistry in this particular case, to women and the working class public through exponentially increasing the amount of people familiar with the topics; thus increasing a population of future scientists who were once excluded. *Conversations on Chemistry* went through 16 editions, numerous printings, multiple pirated printings in the United States and was translated in multiple languages throughout Western Europe (Meyer “The Chemical” 64). Her text, even though she did not intend it to be, became the dominant textbook used in educating women in Chemistry in the United States. She, herself, did not have to break through the bounds restricting women in science--arguably, it is through her insistence in keeping to what was considered appropriate for women that she was able to lay the foundation for a generation of women to break through the male world of science.

Influential men of science at the time also recognized her skill and saw her texts as more than just fictional conversations briefly touching on topics of science, but rather saw how they provided a solid introduction and base level of knowledge in the fields they covered. The monthly Swiss journal for science and the arts, *Bibliotheque britannique*, published a review of *Conversations on Chemistry* in 1806. The review is quick to establish that Marcet is not contributing to the field of chemistry as a professional scientist, as her book "will teach nothing to chemists" but then again, that was not her goal or the point of the text (Pictet translation qtd in Bahar 46).. There were already numerous books written in elevated scientific language to do just that, and Marcet points out in her preface of the text that she was not a chemist. All the review does by making such a statement is establish the impressive role that her work does take on--one of introduction and basic instruction in the field of chemistry. Her work brings a knowledge otherwise elusive to an interested public. She claims the female audience is her target, but as the review states, her text is "perfect for developing a taste for science among those who are already sprouting some interest" (Pictet Translation Qtd in Bahar 46). What is important to point out in the text of the review is that nowhere does it specifically say that it is for women with a sprouting interest in the sciences. The writer of the review recognized the significance of the text for anyone interested, male or female.

Marcet's work had a far greater influence and audience from the start than she ever could have anticipated. The review from *Bibliotheque britannique* even states that

Conversations on Chemistry is useful for those interested in pursuing a profession in science as it provides a solid base level of instruction. Pictet writes how "it may suffice in the instruction of mere amateurs and in the useful preparation of those who wish to further pursue the subject" (translation Qtd in Bahar 46). The previous statement discussed the benefit for those interested, but here, this specific sentence of the review signals that men interested in the pursuit of science as a profession could find her writings useful. The significance of *Conversations* for men is clearly implied in this statement because women did not have a role in professional science and therefore would not have been the intended recipients of such a statement. Regardless of male or female or one's intent for using the text, what is essential to point out is its role in providing the public with access to science in a new way--one that was easy to understand, yet still true to the science by providing accurate descriptions of theories and precise experiments.

Marcet was diligent and dedicated to providing accurate and up-to-date information in her text and the accuracy and detailed understanding of the theories is what sets it apart from others. Marcet clearly understood the science herself and that aids in her ability to relate it in practice terms to others unfamiliar. Her husband's notebooks explain how active he was in the discussions surrounding the book (he was a professional doctor and chemist) but he too mentions the involvement of others and Marcet's correspondence with men of science throughout the community. She regularly corresponded with professional men of science to ensure that she was properly explaining the scientific theories they were experimenting with in lectures. As Bahar argues, unlike other didactic texts, Marcet's writing was integrated into the work of the community of scientific men she surrounded herself with (40).

Marcet did more than just relay information at a base level. She truly understood the information she was explaining in her texts. Her own detailed comprehension enabled her to introduce the information in a way that others could clearly understand. Her publication *On Political Economy* tackled a topic that was fashionable at the time while also highly important to the social change that was ongoing, thus providing women and the general public a way into these salient conversations. Thomas Malthus was so impressed with her writings and ability to understand and clearly explain issues that he encouraged her to write more books on political economy for the public--not just for women:

> I am strongly therefore inclined to advise you to publish them in as cheap a form as you can, for general circulation and to give away. We shall be happy to purchase a dozen of them to distribute to the Cottagers in our neighborhood. I think your doctrines very sound, and what is a more essential point, you have explained them with great plainness and clearness. (Polkinghorn)

Malthus sent this letter to Marcet to compliment her on one of her latest publications, *John Hopkins's Notions on Political Economy* (1833), and to encourage her to publish more. Malthus saw in Marcet the great talent of translating difficult philosophical thought into easy to understand clarity. This is a skill that few people had and is one of the reasons that Marcet was so influential. She not only appealed to her readers, those less inclined to read the more formal publications due to position or lack of education or both, but also to the actual writers of the philosophy, as Malthus states, because she had the ability they lacked to relay their message to the masses.

In Susan Lindee's discussion of the impact of Marcet's *Conversations on Chemistry* on female education in the sciences in the United States, she makes an important distinction between many popular introductory science texts for women and Marcet's. Lindee argues that many popular science books intended for women "were casual entertainment, essentially conservative, [and] legitimated by the presumed domestic and religious applications of scientific knowledge" (23). However, the institutions teaching chemistry to women (which were gaining popularity during the century in America) required approval that textbooks were going to provide "a sustained course of study of science" and "Academy chemistry, at least in those schools that used Marcet's text, was serious chemistry for beginners: an up-to-date review of European chemical theory, illustrated by experiment, requiring an understanding of chemical terminology and facility in the manipulation of laboratory equipment and chemicals" (Lindee 23). This use of Marcet's *Conversations*, even if outside of her original purpose in creating it, shows how her text was being used to teach science, or chemistry in particular, for more applications beyond just how it would help produce the proper domestic housewife. The use of Marcet's text in the classroom greatly contributed to the potential for new roles for women to participate within the sciences.

Marcet's scientific writings were designed for women, children, and an uneducated public as an opportunity to introduce them to theories in science. She did not water down the information provided merely because her intended audience was not comprised of educated males. She introduced and explained the same theories in chemistry that comprised many of the textbooks designed for men's colleges at the time

(Lindee 13). Marcet was different not because she was female, but because she recognized a need to use a different style of language to make scientific theories more accessible and comprehensible. This is not a style of language that only women could learn from, even if it was typically used in texts designed for a female readership. Although Marcet may warn against the practice of chemistry for women by not revealing the "minutiae of petty details" in some discussions, she nevertheless gives a woman the tools and knowledge to cross that boundary if she so desires. Her insistence, though, on "professional men" as the people who should partake in the practical applications of the chemistry such as medicine mixing, is important in its own right. By emphasizing "professional", Marcet is acknowledging the burgeoning field and discipline of science as a profession and therefore of the scientist--a professional of science. As discussed in the previous chapters, professionals of science and scientific societies were working very hard to establish themselves as voices of authority within society and the language of Marcet helps to bring that voice to a much larger audience.

One of the greatest scientists in the nineteenth century was first introduced to science through Marcet's *Conversations on Chemistry.* Michael Faraday (1791-1867), a fellow of the Royal Society and director of the laboratory of the Royal Institution made numerous discoveries and advancements to the fields of electricity and magnetism and is recognized for his discovery of electromagnetic induction; and he explains that it was Marcet's text that first led him down this path (James). Faraday was working at a publishing house as a bookbinder and it is there that he first came across Marcet's text. He claims

> it was in those books, in the hours after work, that I found the beginning of my philosophy...Mrs. Marcet's 'Conversations on Chemistry', which gave me my foundation in that science...I felt that I got hold of an anchor in chemical knowledge, and clung fast to it. Thence my deep veneration for Mrs. Marcet, first as one who had conferred personal good and pleasure on me, and then as one able to convey the truth and principle of those boundless fields of knowledge, which concern natural things to the young, untaught, and inquiring mind. (Qtd in James)

Even if Faraday was the only person to learn of chemistry through Marcet, her influence and contribution to nineteenth century science would be undeniable. But we know this not to be the case, he is just one of thousands of men and women who found their way to chemistry and the "truth and principle of those boundless fields of knowledge" through Marcet's numerous works.

Marcet's first science publication was *Conversations on Chemistry* in 1806. She published the text anonymously originally, but in later editions (she published over 16 throughout her life containing revisions and additions to the theories of chemistry) she included her name as author. She writes The Preface for the text and quickly states that the author is a she, even if she did not originally attribute it to herself. Marcet's language from the very start is self-deprecating and apologetic—yet it is also quite smart. She, a woman in the early nineteenth century, is writing a text on science. The idea of women even being taught science was still new and many in society had yet to take hold of the idea as appropriate. Thus, her language is brilliant because she plays into the fears or frustrations that others might initially have when they see a text on chemistry written by a woman. Further, she immediately acknowledges, in the first sentence, that this text is designed "particularly to the female sex" but she is offering it "to the public" (v). Consequently, in the first half of the first sentence in the preface, she calms down any who may oppose her writing about science because she is writing for the "female sex." Then, she quickly squashes anyone who may claim that is she out of line by apologizing for her text and explaining that her new knowledge of chemistry and book give her "no real claims to the title of chemist" (v). By including this language, she creates a space in which her text is appropriate. Yes, it is written by a woman, but it is for women. And, she calms the more strident opposition who feel women have no place in science by reinforcing that she in no way is attempting to claim the title of chemist through her work. When this text was published in 1806, female writers taking on science were still fairly unique and when they did exist, they were relegated to writing for women and children. Although chemistry was not typically thought of as a science for women, such as botany was, Marcet is purposeful in placing her particular audience in order to establish a place for her work so as not to appear transgressive in anyway.

Marcet explains her motivations for writing a text on chemistry as stemming from her own initial confusion after attending an experimental lecture at the Royal Institution. She felt "it almost impossible to derive any clear or satisfactory information from the rapid demonstrations" (v). It was not until after the lecture when she conversed with a friend—most presumably her chemist husband—that she understood the theories and experiments that she witnessed at the lecture. Through these conversations, not just the lectures, Marcet felt "highly interested in its pursuit" and wanted to know more about chemistry (vi). Once she had learned the basic theories of chemistry through discussions and conversations, she began to fully enjoy and gain more knowledge and understanding from the lectures at the Royal Institution (which at the time were performed by Sir

Humphry Davy). She recognized at the lectures “the great advantage which her previous knowledge of the subject...gave her over others who had not enjoyed the same means of private instruction” (vi). Thus, from her own process of experience from being confused at the lecture, to conversations about chemistry that clarified her lack of understanding, to gaining more insight from the lectures while seeing others struggle, Marcet decided to undertake the job of writing an introductory popular text on chemistry. And because the method of learning through conversation is what worked her her, “it was natural to infer, that familiar conversation was, in studies of this kind, a most useful auxiliary source of information” (vi-vii). Marcet emphasizes that ‘familiar conversation’ is also the right method to transfer the more complicated chemistry discussions to women because women’s education was “seldom calculated to prepare their minds for abstract ideas or scientific language” (vii). And although she is accurate in this statement, writing in conversation is not only beneficial for women, but also for her audience comprised of the male public that probably also lacked the formal education necessary to understand the more complicated theories of chemistry when veiled in scientific jargon. Her choice of style in presenting the theories is aligned with her goal of providing this information to a general readership who is otherwise alienated from it.

Marcet continues The Preface with a discussion emphasizing why women in particular need this text and why it is also appropriate that she provide it to them. First, Marcet states that many women are not in a position to hire a tutor in chemistry to converse with and provide instruction in chemistry. Marcet does not believe that knowledge should be reserved for a specific class of people or a specific sex; rather, she is quite supportive of the opposite as she finds that the difficulty that women have in accessing this information is of primary concern. Second, Marcet, who was a well-educated and well-read woman quite familiar with the sciences, had no knowledge of "any book that could prove a substitute" for the one that she wanted to write (vii). Marcet believed all should have access to knowledge and there was no other opportunity for women and the general public to gain this type of access at the time. Marcet, then, fulfilled the obligation she found to take on the difficult task of writing an introductory book on chemistry.

Marcet details her decisions for how she was going to present the information and determined to start simple and build to more complex compounds and discussions. This meant, as she noted, that her text would not serve as a glossary or encyclopedia of chemistry that one could turn to a page to find out everything about a topic—it would work best to read it from the beginning and process the knowledge. She also notes that at times her characters in the text, the tutor Mrs B. and her pupils Caroline and Emily, might seem too smart or "appeal much too acute: for their age and sex", but she argues that she does this purposely (ix). She wants them to make leaps of understanding, as she did, and she also does not want to get stuck explaining minute details that would have "rendered the work tedious, and therefore less suited to its intended purpose" (ix). Marcet, here, explains that she wants to provide a text that follows a real path of learning and understanding; yet, she also wants her text to be entertaining and encourage curiosity, not stifle curiosity through tedious and boring prose. As self deprecating as Marcet is in the start of The Preface, her language and presentation of purpose grow in confidence throughout. She creates bright and curious female characters to reflect the audience that this text was designed for. She was not writing a textbook, but rather an introduction to the theories of chemistry in order to provide a solid foundation of understanding that would ease comprehension while in pursuit of gaining a deeper understanding of the subject through attending lectures.

Marcet, at the end of The Preface, returns once more to the discussion of her authority in writing the text and whether or not it was suitable for a female audience. Although she writes that she was occasionally "checked in her progress by the apprehension that such an attempt might be considered by some, either as unsuited to the ordinary pursuits of her sex, or ill-justified by her own recent and imperfect knowledge of the subject," she ultimately found her confidence in providing this information in a manner designed for women because new institutions open to both sexes were being created and thus women were no longer necessarily excluded "from an acquaintance with the elements of science" (ix). She may have felt apprehensive, but her ability to establish her authority is strong in The Preface. Additionally, she claims her authority on the subject by explaining that she was probably better for the job of writing an introduction to chemistry than others because the process of learning the theories "were still fresh and strong" so she was in a place to "succeed the better in communicating to others sentiments she herself experienced" (x). Not only does she establish that she is right for the job here, but she claims that her position gives her an even better perspective than men who have been studying chemistry for ages because she understands how people learn new theories and come to understand the information so she can more easily communicate said theories to the audience. Although she remains humble and feigns the fear of how others might perceive her work, she claims her authority to write the text and present it to the public, an audience comprised of a general readership typically excluded from access to such knowledge, with quite convincing evidence.

Even though Marcet specifically mentions her female audience for this text, she is careful not to exclude men, as she knows that they too can gain significantly from this exposure to the sciences. She says, "The reader will soon perceive...that *he* is often supposed to have previously acquired some slight knowledge of natural philosophy" (x, my emphasis). Here, she is establishing two things: one, her last address to the audience in The Preface is to men—a reader that is a *he*. And in doing so, she reestablished the democratic nature of her text, that it is not just for women, but provides a general readership an introduction to chemistry. The second thing she is establishing again is the serious nature of her work. She is not providing an exhaustive introduction to chemistry laden with scientific terms, but she is providing a detailed foundation, one that requires a basic understanding of natural philosophy. And by explaining this, she is emphasizing her own knowledge on the subject and that the information provided is not the MOST basic introduction to what chemistry is, but an introduction that provides the necessary foundation to further pursue chemistry, whether it be as an attendee at lectures, or in another way. Although slight, and easy to consider negligible and overlook, her language is incredibly important because it shows her emphasis on creating a text accessible to all that provided accurate and actual introductions to chemistry beyond what may have been considered necessary for domestic success. Her purpose was to provide a science text on chemistry for the public, and her language establishes her lack of exclusivity, which was rare for science texts of the time.

Marcet introduces her second text, *Conversations on Political Economy* (1816), slightly differently in The Preface than she does in *Conversations on Chemistry.* First, she recognizes that her attempt to discuss the topic of Political Economy "in an easy and familiar form" has not yet been done in English (iii). She knows that she is undertaking a large task and recognizes the responsibility associated with being the first to attempt such a feat. She, then, also acknowledges that "Political Economy, though so immediately connected with the happiness and improvement of mankind, and the object of so much controversy and speculation among men of knowledge, is not yet become a popular science, and is not generally considered as a study essential to early education" (iii). Here she is demonstrating that she has a very different audience and purpose with this text than with her first publication. She cannot claim the need for the text due to popularity in the public and thus a need to provide a text for women. She also does not go as far as to say that this text is essential for female education. In fact, this text, according to Marcet, is not designed for a female audience alone. Rather, she explains how she has written it for "young persons of either sex, for the instruction of whom it has been especially intended" (iii). This is another diversion from her first text where she clearly stated that the primary audience was female, which was appropriate for a woman writer. Here, she strays from that, and explains how this text is for both male and female readers who are essentially unfamiliar with the issues. She does include "youths" in her acknowledgment of the audience, showing that she is still writing within the boundaries of what is considered appropriate for women at the time, but she is slowly pushing against the boundaries forcing them to expand.

Marcet explains in The Preface that she gathered “the principles and materials of the work” from the “great masters” including Smith, Malthus, Say, Sismondi, Ricardo, and Blake (iv). Interestingly, she clarifies that she was her own guide for the work and only after she completed her discussions of numerous theories that she “derived great assistance from the kindness of a few friends” to help revise the work (iv). She is humble still, as she is in *Chemistry*, but a new sense of authority is present, where she is claiming more for her own, which is important in showing her growing progress and command as a female popularizer. Marcet is confident in the accuracy of the information that she discusses in her text, and she does not feel the need to try and assert herself into the conversations by attempting to explain why she is speaking on it with some authority. Rather, she establishes herself as an expert. By not stating such remarks, like she does in *Chemistry* about how she is not an actual chemist and would not claim to be, about not being a Political Economist, she is showing her confidence and ability to speak authoritatively on such subjects. She acknowledges to her reader that some theories were not included if she found that they had not been clearly and soundly established. But for the work she does include, she has “stated [it] conscientiously, without any excess of caution or reserve, and with the sole object of diffusing useful truths” (v). She is asserting her authority to determine what is established and accurate on the topic in addition to her ability to convey the discussions associated with Political Economy accurately and on her own.

Further, Marcet's confidence in her own abilities as a writer who, through her own knowledge, is capable of relating such information to a new audience is made evident through the discussion of her choice to continue with the same use of dialogue as the form for the text as she did in *Chemistry.* She confirms her choice in the conversational style even if other "advisers" were doubtful (v). She claims beyond the ease associated with question and answer in dialogue, she selects the conversational style because she wanted to mimic her own path to knowledge and understanding on the topic and only through conversation could she do that most effectively. Additionally, she argues

> that the colloquial form is not here confined to the mere intersection of the argument by questions and answers, as in common school-books; but that the questions are generally the vehicle of some collateral remarks contributing to illustrate the subject; and that they are in fact such as would be likely to arise in the mind of an intelligent young person. (v)

In this statement, Marcet is arguing that through dialogue, she is able to convey more about that topics than through the more didactic and simplistic tone of books designed for school. She is also recognizing how people tend to learn and grasp new concepts and she designs her texts specifically to follow that process. Additionally, this excerpt shows how seriously Marcet takes her responsibility in writing on the topic of Political Economy. She is not just providing the most surface level of explanations that maybe a school book would, she is more concerned with making sure that her readers are fully exposed to the topics discussed so they can then understand and more completely participate in discussions about the issues. She does not just briefly expose her audience, rather she wants fully to inform her readers and provide a true introduction to the field. With this text, she is not just focused on women, although they are a primary audience for her, she is concerned about making difficult theories that affect the lives of the people available to the public in a comprehensible way. Marcet's *Conversations on Political Economy* is another opportunity to see how she was entirely supportive of the idea that all people deserve the knowledge associated with topics that affect their lives and even when they were traditionally reserved for "men of knowledge". She creates works that bring this information, this knowledge, to the people—both male and female.

Female popularizers of science like Jane Marcet in the Romantic period had a significant and influential role in the science network of the time. Because of the assumption that a woman's role could best be served in educating the young and other women, the female science popularizers were granted great authority—an authority that would otherwise have never been provided to them. Women brought the exclusive world of science to the general reading public, a public that consisted of working middle class men and women. This exposure to the sciences not only helped to cultivate a society that looked to science as a new form of authority, but the mere fact that these people were being educated in new topics and fields and provided a vast expanse of knowledge once withheld from them was significant in developing a society that was educated and could make their own decisions based on reasoning and evidence. Science was not meant for the elite echelon of male society who had the leisure time to sit at lectures and study natural philosophy. As Jane Marcet worked diligently to show, science was for everyone, especially women. Women could be more than note takers and listeners, women could be active and knowledgeable participants in the constantly changing world of science in the nineteenth century.

Victorian Female Popularizers of Science

As the century progressed and more women took on a role within science as writers, the methods and purpose began to shift. Many were unsatisfied with the position of only participating in a way as to teach children or women about introductory science; they felt they had more to contribute to science beyond explaining the theories of others. One such woman, later called the Queen of Science in the nineteenth century, was Mary Somerville (1780-1872). The work of Somerville paved the way for more women to branch out beyond the role of an early popularizer and take a more active position in participating in the advancement of science through new understandings of theories or even new theories altogether. Mary Somerville is best known for her *On the Connection of the Physical Sciences* (1834), an extensive text that historicizes and synthesizes the physical sciences. Somerville's first publication was *The Mechanism of the Heavens* in 1831, which was a translation of LaPlace's work. Somerville was well versed in numerous fields of science and mathematics and published *Physical Geography* (1848), *On Molecular and Microscopic Science* (1869), and an autobiography that was finished just before her death and published posthumously by her daughter titled, *Personal Recollections from Early Life to Old Age* (1873).

Neeley argues that Somerville's role as popularizer differed from most women at the time because her goal was not to write introductory works that provided an initial and basic exposure to theories in science for the uninformed or uneducated public. Rather, Somerville took numerous scientific theories in the physical sciences, combined and synthesized the work creating a comprehensive look at knowledge in the physical sciences (211-12). This work was not just informing an uneducated audience about the physical sciences, but rather it was useful to anyone participating in the practice of science because it was one of the first comprehensive looks at all of the theories in the physical sciences and how the methodology of science connected them. Additionally, Somerville translated multiple works from French into English providing scientists access to new theories that were restricted by language before. Her goal, then, in writing in science was not focused on the non-scientific public, even if they, too, ultimately benefitted from it, but rather her goal was to write for people (who were mostly men) within the field who could garner new information from her unique presentation of scientific works.

Agnes Mary Clerke - A Victorian Popularizer of Science

Agnes Clerke's extensive knowledge in the field of astronomy was evident in her writing. She often drew comparisons from those in the field to Somerville because of her ability to synthesize scientific theories. Some looked at Somerville as the more prodigious popularizer because of the numerous topics that she wrote on and synthesized.

However, as Bernard Lightman points out, the end of the nineteenth century was very different for science compared to when Somerville started writing, and “it could be argued that dealing with the connections within one discipline was the most that could be expected in an age of specialization, even of a well-informed practitioner...the time of the polymath was over” (“Constructing” 474 n 92). Therefore, one cannot discount Clerke because of her specialization, rather we can use it to emphasize how Clerke is very much a product of the late nineteenth century scientific community, one that was quite different from when Marcet began to write in 1806 or even Somerville in 1830. However, like Somerville, and therefore more progressive than earlier female popularizers such as Marcet, Clerke created accounts of the history of astronomy that were found useful to both the public and practitioners of science alike. Clerke was adamant that she was writing for the public, but she was not concerned with distinguishing that she was writing for women. Clerke is evidence of some of the progress made throughout the century for the role and authority granted to female popularizers. Somerville pushed the limits and created change in what it meant to be a female science writer and Clerke embraced and embodied those changes at the end of the century. Beyond synthesizing scientific theories as Somerville had, Clerke advances her position even further by making suggestions for practitioners to take in future work. She was not at the forefront of astronomical innovation; yet, in a way, she was behind the innovator urging him in a specific and fruitful direction. Thus, her contributions to science as a female popularizer are unique and undeniably influential on the science network.

Clerke was born in a small town in County Cork, Ireland in 1842 to a successful family. Her parents were well educated; her father, a classics scholar, believed deeply in educating their children. She was educated at home, but received instruction in piano, Greek, Latin, mathematics and the sciences. Clerke developed her interests in astronomy at a young age as her father included her in his amateur astronomy hobby. Clerke's personal education grew exponentially during the ten years she spent living in Italy with her family. They moved in 1867 and spent time throughout Italy, including Rome, Naples, Lucca and Florence. However, during Clerke's time in Florence, she had access to the city libraries and devoted herself to intense research (Huggins 226). She was particularly interested in Italian Renaissance history of philosophy and science. But it was only after Clerke returned to London with her family in 1876 that she began her literary career (Lightman 470-71). Although she had a varied education, it was her article published in the *Edinburgh Review* in 1880 "The Chemistry of the Stars" that refocused her work back in astronomy and led to her first major publication (Dent). Her career spanned decades and Clerke was constantly writing and publishing in various genres. She published dozens articles in journals like the *Edinburgh Review* (Huggins claims that she published exactly 55 articles in the *Review)* and *Nature;* she regularly contributed entries to the *Encyclopedia Britannica,* and wrote numerous pieces for the *Dictionary of National Biography*. These publications are in addition to her more major scientific texts including *A Popular History of Astronomy During the Nineteenth Century* (1885), which had four major editions, *The System of the Stars* (1890), *The Herschels and Modern*

Astronomy (1895)*, Concise History of Astronomy* (1898)*, Problems in Astrophysics* (1903) and *Modern Cosmogonies* (1905).

At the end of the nineteenth century, a connection or emphasis on God in the sciences was less and less typical and more and more taboo. Many scientists, including the members of the X Club, worked hard to establish science solely in the realm of the natural. Yet, many female popularizers were focused early on in their role of connecting science teaching for women with a connection to the moral and theological teachings of religion. Although Clerke is not focused on the theological connection, she is not afraid of it either. In a review of Clerke's *The System of the Stars,* Mary Huggins, a close friend of Clerke's and active member of the astronomical community, praises Clerke for the way she positioned herself to "stand midway between the lofty levels of the highest attainment and speculation and the lower levels of average human capacity, interpreting the one to the other, and drawing both into a closer union with a common All Father" (Huggins Qtd in Lightman "Constructing" 63). Clerke was a devout Catholic and found her faith as no impediment to her science and devotion to astronomy. Lightman states that "Clerke's effort to put the "new astronomy" into religious framework should be seen as part of her larger project to "renovate intellectual life" so that thinking individuals did not feel compelled to choose between science and religion" ("Constructing" 67). She was not pushing for contemporary views of natural theology[6] but rather redefining the

[6] William Paley (1743-1805) published in 1802 *Natural Theology* where he argues for the role of the divine in the natural world through the role of an intelligent creator. Essentially, everything in the world was the purposeful product of the divine. His philosophy allowed no room for evolutionary theory and garnered a significant following throughout the nineteenth century (Crimmins).

connection between science and religion through using the most up-to-date findings in her field (Lightman "Constructing" 68). Surprisingly, it does not appear that her inclusion of God in her work spurred much criticism as the contributions she made through synthesizing the history of astronomy and illuminating many of the basic teachings of the field were profound.

Huggins speaks to the progress of science in the late 1800s and shows how Clerke stepped into the new role of science writer. She says, "The progress of science and the growth of its literature during the last quarter of a century have been so enormous that a new order of worker is imperatively called for; and Agnes Clerke was an admirable example of such a worker, devoting herself to astronomy…" (Huggins 227). Additionally, Huggins points out that this new order of workers, or female popularizers, were not just producing material for uneducated women and children, Clerke and others were on a mission; "The mission of these special workers is to collect, collate, correlate, and digest the mass of observations and papers; to chronicle, in short, on one hand, and on the other, to discuss and suggest, and to expound; that is, to prepare material for experts, to inform and interest the general public" (227). Huggins is arguing that popularizers of the time had more of a role than just introducing topics to an uneducated public. Like Somerville had before, and Clerke followed, these new popularizers played a significant role in providing connections and synthesizing information in the different sciences for their audience. And this audience was also unique and transformed from the early nineteenth century female popularizers. Huggins substantiates the new position that Clerke adopts in her writing that focused on providing useful information to both practitioners of science and the public alike. Huggins, then, attributes this new, more detailed and elevated form of popular science writing to Clerke. She was a historian of astronomy while she also added to the field by suggesting further avenues for astronomical research and discovery. Huggins writes, "In doing so [Clerke] rendered splendid service, and inaugurated a kind of work which must be more and more needed--a kind of work which not only advances astronomy, but promotes a universal brotherhood and co-operation, golden indeed" (230). Huggins' praise of Clerke may seem overly excited, these are excerpts from the obituary she wrote for a friend, but they are not unsubstantiated. Clerke took on a new role in science writing for women and found a way to straddle the sharp line between professional of science, or scientist, and popularizer of science. The line was even more dangerously spiked for women in the field, and Clerke found a way to be appreciated by all and contribute significantly to astronomy and the larger scientific establishment.

In *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science,* appeared an anonymous review of Clerke's first text, *A Popular History*, in the January 1886 edition. From the start, the review is highly complimentary of Clerke's work asserting that

> this [*A Popular History of Astronomy During the Nineteenth Century*] is undoubtedly the more remarkable work of a popular character that has appeared in this country on the subject of Astronomy… her endeavour has been to enable the reader to follow the course of modern astronomical inquiries, and to realize the full effect of the change introduced by the discovery of a spectrum analysis. The author is evidently a practised writer, who has thought for herself on most of the astronomical problems of the day, and is not afraid of expressing her opinions on them, and she has certainly succeeded in making the work before us a very instructive as well as a very interesting one. ("Notices Respecting" 279)

The reviewer was not skeptical of asserting such praise on a popular science text written by a woman because of the depth of the information provided by Clerke. Her first major popular science publication demonstrates her breadth of knowledge and ability to process and provide commentary on the "astronomical problems of the day" signifying to her new audience that she had knowledge and experience that could not be denied. Thus, she creates a place of authority for herself on the subject. After detailing the topics included in her text, the reviewer concludes with, "to those of our readers who wish to have a clear view of the state of our knowledge before the invention of the spectroscope compared with what it was in the year 1885, we have no hesitation in recommending for their perusal *A Popular History of Astronomy During the Nineteenth Century*" (230). The reviewer does not just say that the text is useful and provides instruction on astronomy, but he goes as far as to use language that emphasizes the success of her text by claiming that he has "no hesitation in recommending" her book to the readership of the journal (230).

Nowhere does the review comment on the sex of the author and whether or not her position in writing a popular science text on astronomy is appropriate. Additionally, the reviewer does not need to argue that the text is only beneficial to those "sprouting some interest" in the field of astronomy, as many of Marcet's reviewers did (Pictet Qtd in Bahar 46). Marcet's reviews were strong for her texts, but they often commented on how they were only useful for less educated or less knowledgeable readers and that was okay for Marcet as those were her primary audiences. However, with Clerke's review, even though her purpose was to popularize astronomy, she shows how the female science writers of her time had progressed because she did not have to write just for youth, women, or even uneducated men. Her text would benefit anyone—a lay person interested in science, a novice woman, or an expert in the field—who wished to know a more detailed account of the history of astronomy. The strength and influence of Clerke's text, and her new audience, is also emphasized by the place of publication of this review. *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science,* which in the present is referred to as *Philosophical Magazine* is a publication that had been in circulation since the late eighteenth century that regularly published works form the most prominent scientists of the time, including Humphry Davy, Michael Faraday, and James Clerk Maxwell among many others. The general readership for this publication was not comprised of the uneducated public, but quite the opposite. The audience of readers would be comprised of members of the society who actively kept up-to-date with advancements in the sciences. For a journal with such a readership to review Clerke's *A Popular History* shows the significance of her book. But, for such a journal to highly recommend Clerke's text, which it did, emphasizes the strength of her writing and breadth of detailed knowledge and speaks to her influence.

Beyond the rave reviews that Clerke received for her publications, she garnered incredible respect and acclaim from the scientific community. She was a member of the British Astronomical Association, and just the fourth woman provided with an honorary membership to the Royal Astronomical Society, Caroline Herschel was the first. Additionally, she was elected as a member to the Royal Institution, which also awarded her the prestigious Actonian Prize of 100 guineas for her work in astronomy (Hollis).

Similar to Marcet, Clerke had a vast international network of friends and scientists who could ensure she was working with cutting-edge materials while also providing support and suggestions. She not only had friends in the field that would help her, but as Huggins points out, they truly liked her and wanted to help her succeed in any way possible. Huggins writes, “[Clerke’s] sympathies were so keen, her interest so warm, her longing for further truth so intense, that everyone liked to offer her all he could” (227). Clerke was well respected throughout the astronomical community that spread well beyond Britain.

Clerke had numerous scientists that she corresponded with regularly including the Huggins, Holden, Burnham, Barnard, Pickering, Lockyer, Gill, Vogel, Schonfeld, and Keeler. Clerke corresponded with this network for more than just help in her work; she was often consulted for her own expertise in reading astronomical photographs. She developed an excellent skill and would often be asked to help to decipher the photograph, and because of her friendships across the globe, she was often the first in Britain to see some of the newest photographs of the galaxy and universe around. James Keeler (1857-1900), an American astrophysicist, regularly corresponded with Clerke. In his biography of Keeler, Donald Osterbrock claims that on many occasions, “although he was not ready to publish [his] result, he hastened to write Agnes Clerke and inform her of it. As the chief astronomical writer of the English speaking world, she was an important opinion molder, and Keeler wanted her on his side” (315). Keeler’s insistence on sending preliminary results to Clerke because he wanted her to support his work says a lot about how experts and professional scientists in the field respected Clerke and her expertise.

Further, Osterbrock, a biographer of an early astrophysicist, refers to Clerke as the chief astronomical writer, which shows her significant influence and contribution to the field of astronomy and thus science and the science network.

The admiration that Clerke received for her work placed her on a different level than early popularizers of science who were separated and looked at as only useful in producing texts for a female or juvenile audience. Clerke's command of the field of astronomy and the praise she received from practitioners in the field expanded the horizons for female popularizers of the time, creating space where a female writer could participate in the field and write for a much larger audience. Lightman argues, "Clerke was not merely a mediator between the scientific experts and the uninformed public but also stood as an interpreter of the larger meaning of recent astronomical discoveries to the professional astronomers themselves" ("Constructing" 70). Even with the more specialized and elevated nature of Clerke's later texts, she still emphasized that they were for the public. She recognized the importance in sharing her knowledge and the science of astronomy with more than just other professionals in the field. Additionally, it was her ability to make a more in depth analysis of a scientific field available and entertaining for the public audience that makes her so important to the science network. She may not have been writing just for a female audience, but women had access to her materials, and her work was able to expose and introduce women to more comprehensive scientific theories. Additionally, Clerke's own participation within the field of astronomy beyond synthesizing theories, created space for other women to take more active roles within the different fields of science.

Clerke was an accomplished writer and contributor to numerous publications before she took on the task of publishing her first book. Many argue that she was working on the book for four years before it was ready for publication. The extensive topics covered in *A Popular History of Astronomy in the Nineteenth Century* would easily support such efforts. This text, published in 1885, would be Clerke's first, and for many, her most important contribution as a popularizer. *A Popular History* went through four editions, the last being published in 1903. It was as highly popular as it was regarded by others in the field. Clerke begins The Preface by acknowledging the rapid growth and progress that astronomy had underwent during the 100 years prior to her writing. With such progress, she argues, comes the need for "untechnical treatment" because of popularity and she claims that this is the hole she is filling. She writes that *A Popular History*

> embodies an attempt to enable the ordinary reader to follow, with intelligent interest, the course of modern astronomical inquiries, and to realise (so far as it can at present be realised) the full effect of the comprehensive change in the whole aspect, purposes, and methods of celestial science introduced by the momentous discovery of the spectrum analysis. (v)

From the start, Clerke asserts her book is for a general reader, one not versed in scientific and technical language, but rather one "with an intelligent interest" in the subject (v). Marcet, too, started The Preface to her first book with a discussion of audience, and they are similar in that they both present their work to the public, clearly establishing themselves as popularizers of science. However, nowhere else in the entire preface does Clerke once mention that her work is for a female audience—she actually never mentions women at all. The brief statement that Clerke makes on her audience is the only statement in The Preface, nowhere does she attempt to justify her audience choice or even explain her audience choice as a female writer. Further, Clerke never mentions or refers to herself by a pronoun—yes, she published under her name so the audience is clearly aware of her female sex, but she does not feel the need to address it in The Preface of her text. Her work and her role as a purveyor of information on astronomy is what she focuses on. This presents a stark contrast to the earlier female popularizers in the century like Marcet. Clerke's confidence is evident and her authority assumed rather than asked for.

Clerke transitions from the brief discussion of audience to an explanation of why this particular text and why it is important then. She acknowledges the work of a fellow male popularizer, Robert Grant, who published *A History of Physical Astronomy* in 1852, but claims that due to the progress and changes in the field since then, a new text was necessary. She goes on to justify this statement by explaining how since the development of the spectroscope, astronomy had grown in popularity "both in its needs and in its nature" (v). Clerke details the complex growth in popularity that astronomy underwent:

> More popular in its needs, since its progress now primarily depends upon the interest in, and consequent efforts towards its advancement of the general public; more popular in its nature, because the kind of knowledge it now chiefly tends to accumulate is more easily intelligible…than that evolved by the aid of the calculus… (v)

Because the nature of science was more public and interest depended on that, astronomy too needed to adapt. Clerke presents the above sound reasons as to why a new popular text on the history of astronomy was a must. What one can also derive from this is the self-assurance Clerke has as she does not hesitate to take on the serious role of promoting the field and providing for it to encourage continued success and popularity. Notice that

Clerke does not apologize for her role or desire in providing this piece, rather she asserts a need, one she has the scope to fulfill, and she continues on.

Clerke's assertive and confident tone runs throughout The Preface and into the text of the book. She argues for her use of simple language, not because she is unfamiliar with the more technical language but rather because it is simply "practicable" and "being practicable; it could not be otherwise than desireable to do so" (vi). Her smart tone continues when she explains that the "abstruse mathematical theories" that were most typically associated with astronomy would not be included in detail in the book. And like she did with her argument for simple language, she claims that this is the right way and not because she does not know or understand the math. She actually argues for its "fundamental importance" as it "constituted the sum and substance" of astronomy before (vi). She knows the math and recognizes its important place in the history of astronomy, so it is not that she is avoiding it due to a lack of comprehension. She avoids the complicated theories because due to the new innovations and inventions in the telescope and the spectroscope, the math is no longer necessary to explain the theories of astronomy. And because her goal is to make this text available to the "ordinary reader" it only makes sense to leave it out, just like it was only "practicable" to use simple language (v, vi).

Clerke moves on to a discussion of method for her book and emphasizes the significance in writing a history of astronomy rather than a treatise on astronomy: "In a treatise, *what* we know is set forth. A history tells us, in addition, *how* we came to know it. It thus places facts before us in the natural order of their ascertainment, and narrates instead of enumerating" (vi). For Clerke, as described here, it was important to do more than just present information, but through a narration of the history, she is able to provide her readership a more detailed understanding of the process of knowledge acquisition in the field of astronomy and therefore provide more foundation for a reader if they choose to then pursue astronomy. By understanding the process through which astronomers came to know the theories, someone can better understand how that process would continue in the future. Through this method, Clerke provides more opportunity to explain her own suggestions and forecasting for the future of the field. Additionally, this need of Clerke's to provide an emphasis on why she wrote a history versus a treatise shows how conscientious and particular she was in the formation of the text. And she wants to relay that to the reader. This was a process that was well thought through as to what was best and most beneficial every step of the way, and the reader can then find solace in the fact that they are getting a sedulous and comprehensive look at astronomy.

Clerke's dedication to the project is again shown when she describes how she gathered the information for the history. She writes, "The system adopted has been to take as little as possible at second-hand. Much pains have been taken to trace the origin of ideas, often obscurely enunciated long before they came to resound through the scientific world, and to give to each individual discoverer, strictly and impartially, his due" (vii). Clerke's commitment to providing accurate and sound information for her reader was unwavering. She was determined to provide the best work she could for the public and because of that, Clerke's research for the text was intense and conducted with extreme diligence. She did not rush this text just to publish something, she took her time to ensure the best result. Notice, unlike Marcet, she does not attribute much of the comprehension of the materials to others that she worked with throughout the process. She does thank two professors "for many valuable communications" at the end of The Preface, but she does not give them credit for the work, nor does she allow it to take away from her own place as an authority on the subject. Clerke is confident in her breadth of knowledge on the topic and is unconcerned about her role as female writer. This shows a vast change from Marcet and other early female popularizers in science.

Clerke's second major publication came in 1890 when she published *The System of the Stars.* Similar to the preface of Clerke's first book, The Preface to her second starts with a discussion of the advancements in the field of astronomy that make the particular focus of the book pertinent. What is interesting about this preface, now that Clerke was a recognized female popularizer, is that she spends half of The Preface arguing for the importance of popular writing in the changing fields of science. First, Clerke argues that to keep up with the constant advances in astronomy, one needs a "preliminary knowledge" and unfortunately that is only "possessed by few" (ix). Thus the purpose of Clerke's second book is made clear—"to bring it [preliminary knowledge of astronomy] within the reach of many is the object aimed at in the publication of the present volume" (ix). What is different, then, about this text specifically for Clerke is that her sole aim is to provide information in astronomy to a popular audience. She is not providing an additional history nor is she focusing on developing new directions in the field for practitioners and experts. *The System of the Stars* is essentially an introduction to astronomy that will provide the public the necessary knowledge to allow them the opportunity for "due appreciation" of "the brilliant significance of the results achieved" in astronomy, or what she refers to as "sidereal science" (ix). Now, that is not to say that experts or practitioners could not gain something from her text, she is just particularly focused on providing an introductory text to create a knowledge that allows more people to be able to appreciate the ever constant advancements in the field. Clerke's language is democratic and determined throughout The Preface. She makes seriously provocative statements about the sciences and in particular, astronomy. Because she has developed significant respect at this point in her career, five years after the publication of the extensive *A Popular History,* Clerke is bolder in how she provides her commentary about the changing picture of science. She claims that "Astronomy is essentially a popular science," which means that her role as a popularizer is vital for the continued success and innovation of the field. To claim such a significant role in the field of science, even if it is only through implication, is bold for anyone, but a for a female writer—it is daring.

Clerke's audacious language is present throughout The Preface. Right after she commandeers astronomy for the people, she begins a significant statement on the role of the public in science and astronomy in particular. She argues,

> The general public has an indefeasible right of access to its lofty halls, which it is all the more important to keep cleared of unnecessary technical impediments, that the natural tendency of all sciences is to become specialised as they advance. But literary treatment is the foe of specialisation, and helps to secure, accordingly, the topics it is applied to, against being secluded from the interest and understanding of ordinarily educated men and women. Now, in the whole astonishing history of the human intellect, there is no more astonishing chapter than that concerned with the sidereal researches of the last half century. Nor can the resources of thought be more effectually widened...than by rendering it, so far as possible, intelligible to all. (Clerke ix)

To unpack the significance of this thought, each part must be broken down. She first claims that "the general public has an indefeasible right" to sidereal science (ix). She does not just argue that they have a right—but rather an innate right, one therefore that cannot be denied to the general public. And she does not say just to astronomy, but that they have the right to "access...its lofty halls" (ix). There is a right beyond just having exposure to the sciences and knowledge associated, but there is a right to have access to where and how that prestigious science takes place. And in order to make astronomy accessible to all who have this indefeasible right, she makes it clear that it is a necessity "to keep cleared of unnecessary technical impediments" (ix). The language must be comprehensible for all people because it is a popular science; but as she has made clear through her work, technical impediments are also unnecessary in general in order to participate in astronomy. Simple language does nothing to deter from the serious discoveries and importance of the science itself. Clerke associated the technical impediments with the specialization of science. And according to this statement, there is nothing particularly positive about the trend of specialization. Rather, works of literature like Clerke's on science help to stave off specialization keeping the science available and not "secluded" from the public (ix).

As Clerke, like her earlier predecessor Marcet, makes clear, a basic knowledge or background education is necessary to understand the work that comprises the text. However, one should not be required a specialized science degree to participate in learning astronomy. Clerke did not go into nearly as much depth on her audience and their rights in her first text, as she simply stated that *A Popular History of Astronomy in* *the Nineteenth Century* should be accessible to the general public. However, due to Clerke's detailed sermon on who deserves a right to this knowledge in this preface, her language becomes more specific regarding the intended audience. She typically sticks to the term general public, but she becomes more precise towards the end of her statement when she states that astronomy should be available to "ordinarily educated men and women" (ix). She distinguishes that the general public she is writing for is comprised of both men and women.

Clerke argues that the science of astronomy should not exist behind closed doors and shared with only an elite few. By making such strong comments about astronomy in particular, Clerke is able to comment on science as a whole. Science was once reserved, and not long before her time, for an elite few, but popularizers of science were changing that and breaking down the barriers for both men and women. Women writers were assuming more authority in their roles as science popularizers and by making science available to a popular audience, they were encouraging more people, women included, to find their own role in the sciences. Clerke argues that astronomy, and thus science, should be "intelligible to all" (ix).

After Clerke's sermon on the necessary accessibility of astronomy, she continues The Preface of *The System of the Stars* with a discussion of methodology. The goal of her text was to provide "a general survey" of sidereal science and to "instruct by illustrative examples, to select typical instances from each class of phenomena, dwelling upon them with sufficient detail to awaken interest and assist realisation, while avoiding the tediousness inseparable from exhaustive treatment" (x). She wants to provide the important information necessary to develop an understanding of astronomy, but she does not want to bore her audience. She is particular that she wants to ensure that through her text, the reader can both engage with the material and come to an understanding of the science while also developing a deeper interest and curiosity. Clerke is careful to ensure that her text is both instructive and entertaining. Just as she did in her first book, Clerke simply provides her choice of method, explains why it makes sense, and moves on. Her confidence and unapologetic tone throughout is pioneering for a female science writer. She ends The Preface thanking a few colleagues who provided support throughout the process, just as she did in *A Popular History.* Of particular interest in this brief ending and statement of names is that she thanks Lady Huggins, the only woman included in the list—but one more than in her first text. Clerke is constantly an advocate for women in the sciences even if in the slightest and inconsequential manner of thanking a woman in The Preface. She is bringing women into the sciences by including them in her audience directly and listing them alongside other greats in astronomy.

Although Clerke received numerous reviews that praised her ability to write for both the public and experts in the field of astronomy, she too received some reviews that criticized her simple language and lack of mathematics in her texts, relegating her to no more than a traditional female popularizer of science. This opposition amongst some of her contemporaries speaks to the world in which she was writing—one where popular texts were not accepted by all and a female writer was too closely connected to the popularizers that came before to fully recognize her contributions and move past the constraints put forth by the professional men of science. Enough of her contemporaries recognized and respected her significant contributions to astronomy that some who opposed considering her work as serious science do not detract from her influence. Clerke, at the end of the nineteenth century, continued the progress and role of female popularizers and women in science that her predecessors, like Jane Marcet, began 100 years earlier. Her determination that all people should have access to science helps to democratize the role of scientist at the end of the century. Clerke may be recognized historically for her role as female popularizer of science and historian of astronomy, but her work helped to define the field of modern astronomy and inspire new scientists who existed outside "the lofty halls" that once restricted so many because of the access she granted. Clerke's contribution to the science network in the nineteenth century is undeniable.

Female popularizers of science had "an important role in shaping the terms of discourse in science and technology by providing conceptual frameworks for discussion and for teaching" (Neeley 214). But, women science writers did more than that, through the introductory and synthesized works of these women, they have taken on an active role in shaping the disciplines within science and the definition of who a scientist was. The texts of the female popularizers were for many the first introduction to the particular field of science they were discussing, which means that what the popularizers chose to include was highly influential in defining how a general public understood what constituted that field of science be it astronomy, chemistry, botany, or others. For early writers in the century, this was even more so the case because science was at a stage of definition and distinction. What Marcet chose to include in her introductory text to chemistry "helped define chemistry as a subject in its own right" (Meyer 64). This can be understood through her role in determining what was included within the discipline by what was included in her introductory texts. Later in the century as these disciplines became more solidified, the work of the female popularizers helped to introduce these new distinct fields of science to the general readership. In addition to shaping disciplines, these women played an active role in understanding and defining a scientist.

The role of female writers during this period provided an important bridge between the science of professionals like Caroline Herschel and James Clerk Maxwell and the general middle class public. By presenting science to a general public, these women also then created a space for those individuals to learn about and potentially pursue science. A profession in science was now no longer restricted to the upper echelon of society who had the money to pursue science in their leisure. Combined with the professionalization of science that came with the century, these women enabled men and women to pursue science in new ways, thus opening the field who would claim the title scientist to include a new generation of public first exposed to science through the introductory texts of the nineteenth century. Jane Marcet and Agnes Clerke ultimately influenced the way that culture perceived science and the scientist because much of the population was being introduced to science through their texts. The members of scientific societies were often isolated, or too exclusive to benefit science's popularity in the way that these women writers could. Similar to the way that the female popularizers affected the cultural perception of science and the scientist is the way in which fictional literary depictions of the scientist confronted society with scientific advancements and the dubious nature of such ideas of progress. Fictional depictions show how imbedded science becomes in different aspects of culture.

FOUR

The Collective of Fictional Literary Depictions of Science and the Scientist in Nineteenth Century Britain: *Frankenstein* and *Alastor; or the Spirit of Solitude* to *The Picture of Dorian Gray* and *The Island of Dr. Moreau*

Examining science and the scientists present in literature is central to understanding how people came to define the scientist throughout the nineteenth century. As Robert Richards argues, when science "has its lifelines secured by reattaching them to the thought and culture that animated it, I believe we will discover that many of its main themes have been played out in a Romantic mode" (4). This applies in general to the need to reattach that which for so long was removed from attempts to understand science and the scientist. Even though fictional literature is typically excluded from anthropological studies of science and the scientist, fiction is crucial to understanding a key aspect of science. Science, as established throughout the previous chapters, did not exist in a vacuum void of cultural influence. A definition of the scientist is incomplete if it does not acknowledge the way in which many people interacted with a scientist—through fiction. Fictional literature often, if not always, has a significant role in providing a commentary on culture or society. Through fiction, writers are able to embody the hopes and fears of their people. The writers of the nineteenth century engaged with questions about science and ideas of its progress. Because fiction is one significant way that many were introduced to science and the scientist in more detail, those depictions must be included in this study. If one considers fictional literature as a reaction, in some way, to society and culture, then investigating that reaction is key to understanding the phenomena of the time. Therefore, investigating and analyzing the fictional literary depictions of the scientist as a key collective in the science network is paramount to a comprehensive analysis of science and the science network to better define the emerging scientist.

Romantic Fictional Literary Depictions of Science and the Scientist

The traditional narrow view of the Romantic period, which some still hold today, E.O. Wilson for example argues in *Consilience*, is that Romanticism was in opposition to the enlightenment and rational thought. However, as Donald Goellnicht explains,

> any close and comprehensive reading of Romantic poetry reveals that, in branding the period the era of imagination, of anti-intellectualism...we were seeing Romanticism through tunnel vision. This narrow view has been seriously challenged... as critics have increasingly come to recognize the intellectual significance of Romantic thought. (3)

Through the work of the scholars of the last few decades, a discussion that includes Romanticism and science is no longer taboo or provocative. Yet, for many, the two still do not quite fit together. Research has produced volumes of information that tie Romantic writers with the science of the time through social interests, and deeper engagement in literature. One of the most popular writers during the Romantic period was Erasmus Darwin. In chapter one, Darwin's role in the Lunar Society as a budding scientist producing new mechanisms for industry as well as a theory of evolution were discussed. But beyond that, Darwin was a highly regarded poet. Even though Darwin is not typically considered part of the Romantic movement, he was one of the most popular writers of his time. His poems including, *The Loves of the Plants,* which was later republished in an edition with *The Economy of Vegetation* as *The Botanic Garden,* were highly popular and translated into numerous European languages, and had editions published in America. In the advertisement for *The Botanic Garden,* Darwin wrote, "The general design of the following sheets is to inlist Imagination under the banner of Science; and to lead her votaries from the looser analogies, which dress out the imagery of poetry, to the stricter ones which form the ratiocination of philosophy" (Qtd in McNeil). Darwin's goal was to combine imagination and science in order to ultimately lead the readers to a more logical understanding of the science he included in his poetry. This goal is quite similar to the reasons that James Clerk Maxwell stated for using the imagination and analogy in his writings of scientific theories.

Darwin was not a singular example of combining science and literature during the Romantic period. Laura Otis argues that "In the popular press, however, the two [science and literature] commingled and were accessible to all readers. Scientists quoted well-known poets both in their textbooks and in their articles for lay readers, and writers we now identify as primarily 'creative' explored the implications of scientific theories" (xvii). Coleridge, an established Romantic poet, published and presented numerous lectures and writings on the current scientific theories and trends of his time. Additionally, Coleridge was closely aligned with practitioners of science during the period. He was friends with Sir Humphry Davy and would participate in some of his experiments involving different gasses. Keats may be the one Romantic poet that many still argue rejects science in his writings. This statement automatically seems odd because he spent much of his life training to be a physician, and his work promised a successful career. As Goellnicht describes, Keats studied medicine for the same duration of his life as he produced poetry (7). Yet, most critics have failed to acknowledge the influence his scientific and medical training had on his mind. Goellnicht explains how “This has been a grave oversight for medical knowledge provided Keats not only with specific images and concepts that found their way into his poetry and letters, but also with ideas and attitudes that influenced his broader outlook on life” (7). The importance of a wide range of knowledge was critical to Keat’s personal view of the world. He writes in a letter that “every department of knowledge we see excellent and calculated towards a great whole...and helps by widening speculation, to ease the burden of the mystery” (Qtd in Goellnicht 6). This statement makes it clear that Keats did anything but reject science. His poems may have been more focused on aesthetics and the imagination, but his scientific background was key to his understanding of the world, and thus impossible to keep out of his writing.

Charlotte Smith (1749-1806), a female Romantic poet, is most famous for her poem that ponders issues of natural history composed while she gazes over the cliffs of the southern-most point in Sussex across the English Channel. These questions become the primary focus of this poem and present the poem as a form of thought experiment about the formation of earth. Smith notes in a footnote to the poem that she was writing it while pondering “an idea that this Island [Britain] was once joined to the continent Europe, and turn from it by some convulsion of Nature” (244). Smith confesses that she could not really understand this connection as she “could never trace the resemblance between the two countries" (244). Smith's lack of ability to see and understand the connection between her home island and the continent of Europe requires her to find a different way to come to an understanding. Just as James Clerk Maxwell would decades later, Smith uses her imagination and conducts a thought experiment about the scientific conundrum she faced. The result of this experiment is one of the most significant poems of scientific contemplation in the Romantic period: "Beachy Head".

Darwin, Coleridge, Keats, and Smith are just a tiny sampling providing examples of how science was interwoven into Romantic literature. As briefly mentioned earlier, and in previous chapters in this volume, science made its way into the households of the period through publications, public demonstrations and lectures, and through education. The vast influence of science on a range of aspects of society makes it absurd to assume that science did not make its way into the literature—poetry and fiction. The obvious discussion of science occurring in Romantic fiction is through Mary Shelley's *Frankenstein*. This chapter will provide a brief close reading of Victor Frankenstein and his science, showing how he depicts many of the ideas that surrounded science during the period, while also confronting numerous fears of the public about the progress, or rather questionable progress, of science and the scientist. Shelley explains in the preface of her novel that she, along with her husband, Percy Shelley, Lord Byron, and John Polidori had been discussing the work of recent scientists in the vitalism debate. This proves that she was acutely aware of the science of her time through readings and discussions with her peers. Because of the popularity of *Frankenstein*, in addition to its obvious connections with science and the scientist, I would be remiss to fail to include a discussion of it in this examination of fiction. However, this chapter will also provide a more detailed close reading of Percy Shelley's poem *Alastor; or the Spirit of Solitude*. This poem is not typically discussed as a scientific poem; however, I will show how many of the characteristics of the main subject of the poem directly relate to traits associated with Romantic science and the scientist. These two texts will help to show the ways, both obvious and subtle, that science and ideas surrounding the definition of the scientist found its way into culture through fiction.

Close Readings of *Frankenstein* and *Alastor; or the Spirit of Solitude*

Mary Shelley started the novel *Frankenstein* when she was only 17 years old in the summer of 1816. The circumstances for the start of the novel are almost as famous as the novel itself. 1816, considered the "Year without a Summer", was unique because of how the massive volcanic eruption in 1815 of Mount Tambora in Indonesia disrupted weather patterns significantly enough to prohibit any summer heat. The story of the birth of Mary's novel, which is documented in her journals and letters in addition to Lord Byron's, John Polidori's and Percy Shelley's, starts one thunderous evening in Switzerland at Villa Diodati. Byron writes that they were reading a lot of German Ghost stories during the storms that summer. They would read these horror stories out loud to each other and they challenged each other to a competition of who can write the best ghost story. Shelley claims that the story of Victor Frankenstein and the creature came to her in a "waking dream" that night. And after two years, in 1818, the first edition of her novel *Frankenstein* was published.

Early on in the novel as Victor Frankenstein, the protagonist, relays his scientific studies, Shelley's knowledge and familiarity with the writings of both Sir Humphry Davy and Luigi Galvani become inherently clear. As Jay Bland describes, the premise of *Frankenstein* "is based firmly on the writings and experiments of…physiologist Luigi Galvani. Shelley begins her tale with the science…and the science in the novel is extrapolated from current scientific knowledge and theory" (302). Both prominent scientific theorists of Shelley's time, the studies and writings of Davy and Galvani are woven in throughout the creation of the monster in *Frankenstein.* In "Discourse, Introductory to a Course of Lectures on Chemistry," Davy explains the study of chemistry as one that leads man "to interrogate nature with power, not simply as a scholar, passive and seeking only to understand her operations, but rather as a master, active with his own instrument" (142). Jan Golinski in "Humphry Davy: The Experimental Self" highlights how "similar words were later put into the mouth of the character Professor Waldman," the professor who inspires Frankenstein to research the new science of the time (21). Further, Golinski writes, "in the same lecture, Davy announced that recent chemical discoveries had opened up the prospect of artificially imparting the properties of life to nonliving matter" (21). Frankenstein embodies the description and desires of the chemist put forth by Davy in his lectures; Frankenstein is a scientist who is led by his desire to become a master of the workings of nature rather than just share in her knowledge. Frankenstein desires "a new species would bless me as its creator and source; many happy and excellent natures would owe their being to me" (Shelley 32). He wants to dominate nature and take over the responsibilities once completely belonging to nature.

Furthermore, Davy elaborates that because chemistry is a "sublime philosophy" where one is full of "sublime imaginations concerning unknown agencies" that the pursuer of such a science will obviously "be ambitious of becoming acquainted with the most profound secrets of nature, of ascertaining her hidden operations" (Davy 142). As mentioned previously, Frankenstein wants to master nature, usurping its power, and in order to do so, as Davy explains, he must "ascertain her hidden operations" (Davy 142). Shelley emphasizes this aspect of chemists when she uses the character of Professor Waldman as a way to explain to Frankenstein how chemists are those who "penetrate into the recesses of nature and shew how she works" (28). Frankenstein's devotion to grasping all that nature offers is deepened; while communicating his narrative to Captain Walton, he claims that "one secret that I alone possessed was the hope to which I had dedicated myself…I pursued nature to her hiding places" (32). For Davy, the new science of chemistry replaced the old of alchemy where scientists were confined to the laboratory, in an attempt to obtain "earthly immortality" (143).

Pursuing nature in its habitat, not only in the laboratory, was a more advanced and respectable method for the new science. Ecology, a term that represents the study of the relationship between living organisms and their environment was first used in the English language during the nineteenth century ("ecology, n."). The need for a new term to describe those who study nature in nature is evidence of the transforming ways of science leading practitioners out of the confines of the laboratory. Frankenstein originally attended university in order to study alchemy and the ways of the natural philosophers he had spent his childhood reading, but was quickly shifted away to the study of chemistry by his professors at the university; however, differing from what Davy believes, he has progressed from the studies of alchemy to chemistry, a transition from an isolating science requiring only a laboratory to a science encouraging discovery in the natural world. Frankenstein only initially pursues knowledge outside of the laboratory, but once Frankenstein discovers nature's secrets, he reverts to the "unhealthy vapours of the laboratory" to seek immortality reverting back to the ancient ways and desires of alchemy he had initially left behind (143). More so, Shelley, through Frankenstein allows for the reader to witness the destructive effects of pursuing such a higher knowledge, one not intended for man to understand. Frankenstein ponders, "How dangerous is the acquirement of knowledge and how much happier that man is who believe his native town to be the world, than he who aspires to become greater than his nature will allow" (Shelley 31). Frankenstein warns against his own "unremitting ardour" that carried on his undertaking while he is fully absorbed in it (Shelley 32).

Levine in *Dying to Know* explains the type of behavior Frankenstein exhibited as something that was prevalent during the nineteenth century in the expansion of knowledge. Levine says that scientists, applied to Frankenstein here, would have "a passion for knowing so intense that one would risk one's life to achieve it; and second, a willingness to repress the aspiring, desiring, emotion-ridden self and everything merely personal, contingent, historical, material that might get in the way of acquiring knowledge" (2). Frankenstein understands the potential danger in his pursuit, and the obsession that has developed as he has become more knowledgeable and more skilled in the workings of the science of his time. He alienates himself from all human company, from all worldly desires, and he continues his pursuits, regardless of the risk. This alienation is a feature of the Romantic scientist described early in chapter two through the work of Turner, Bohls, and Fulford, et al. The new science of chemistry has allowed Frankenstein to succeed in his pursuits for "earthly immortality" as Davy describes, in a way that alchemy and the old science never could have and thus he continues his pursuit as he grows closer and closer to success (143). Frankenstein embodies the characteristics that many perceived defined a Romantic scientist.

Davy maps out a methodology for the search of the origin of life, he says, "the study of the simple and unvarying agencies of dead matter ought surely to precede investigations concerning the mysterious and complicated powers of life" (141). Frankenstein partakes in these very methods and even extends them one more horrifying step; he explains "to examine the causes of life, we must first have recourse to death. I became acquainted with the science of anatomy: but this was not sufficient; I must also observe the natural decay and corruption of the human body" (30). Jurgen Meyer explains in "Surgical Engineering in the Nineteenth Century" that the use of dead matter for study was commonplace, Frankenstein "develops his knowledge in the field of 'morbid anatomy', an important part of surgical training in the first decades of the nineteenth century" (175). Frankenstein admits that he was not affected by the horrors of death, but rather embraced it for what it potentially offered him—and it was ultimately through his time spent with the dead matter that he claims to have realized how to instill life:

> I paused, examining and analyzing, all the minutiae of causation, as exemplified in the change from life to death, and death to life, until from the midst of this darkness a sudden light broke in upon me…I succeeded in discovering the cause of generation and life; nay, more, I became myself capable of bestowing animation upon lifeless matter. (30)

Although Frankenstein's practices may be appalling to a modern reader, because his work was rooted in the practice of the time, to contemporary readers of Shelley, this association with dead matter aligns him less with a maniac and more closely with a scientist.

Merely gaining a knowledge of the unknown, the science of nature and life was not sufficient for Frankenstein; he had yet to fully achieve his desired goal. Now that he understood how Nature worked "and alone should be reserved to discover so astonishing a secret", he would begin implementing the power reserved for only him and nature (30). At this point in Frankenstein's studies, the work and research of Luigi Galvani comes to the forefront. Galvani, in "De Viribus Electricitatis" describes his research and findings on electricity in the animation of life. He writes, "From what is known and explored thus far, I think it sufficiently established that there is electricity in animals, which…we may be permitted to call by the general name of animal electricity. This, if not in all, yet is contained in most parts of animals; but manifests itself most conspicuously in muscles and nerves" (136). Galvani famously demonstrated his theory that electricity resided in animals by using detached frog legs that, when attached to a metal conductor, would reanimate and move. As described by Marcello Pera in *The Ambiguous Frog,* "At the very moment the foot touched the surface, all the leg muscles contracted, lifting the leg" (82). Frankenstein is in full alignment with Galvani in his work as he expresses "with an anxiety that almost amounted to agony, I collected the instruments of life around me, that I might infuse a spark of being into the lifeless thing that lay at my feet" (34). As Daniel Dinello states, "…Frankenstein replaces occultism and alchemy with electricity in order to bring his technological creature to life" (41). According to Galvani, Frankenstein's expeditions with the horrors of decaying human matter and the collection of such things were an appropriate method because animation of life "requires no previous device…but it is ready as if by nature and continually prompt, and is produced on contact alone" (138). The immense amount of time Frankenstein spent searching through the "dark recesses of nature"; the collecting of body parts through gruesome means to meticulously bring together muscles and arteries, form limbs, and ultimately a complete, yet still inanimate body would culminate with the infusion of a "spark" bringing the science of Galvani and "animal electricity" to the lifeless creation (34). Galvani's scientific theories (and Shelley's awareness of such science) lay the foundation for Frankenstein's success: a spark infuses life into his creation; "I collected the instruments of life around me, that might infuse a spark of being into this lifeless thing…by the glimmer of the half-extinguished light, I saw the dull yellow eye of the creature open; it breathed hard, and a convulsive motion agitated its limbs" (Shelley 34).

Through the character of Victor Frankenstein, Shelley confronts the fears of the potential consequences that are associated with a blinding and obsessive pursuit of scientific progress. She in no way is arguing against science, but her accurate—as accurate as she could—account of how life can be created outside of the natural, is important so that her novel is not too far fetched to connect with the possibility of reality. Robert Walton, the captain of the ship through which Frankenstein communicated his story, is also a Romantic scientist on a quest for greatness. He was at the point of sacrificing the lives of those on his ship in an attempt to reach a passage that would bring him substantial admiration. Yet, because of Frankenstein, Walton is brought back to reason and is able to stop before his obsession ruins the lives of many, as Frankenstein's obsession had. Shelley then shows with Walton's character that through reason and caution one can successfully pursue science.

Similar to Captain Walton's journey presented in Mary Shelley's novel, Percy Shelley's 1815 poem *Alastor; or, The Spirit of Solitude* highlights distinct characteristics that are key in understanding the emerging scientist in the nineteenth century as well as the essential relationship between travel and the quest for discovery and the development of the scientist during the Romantic period. Specifically, as discussed in more detail in chapter two, travel and a quest or journey to discovery became significant characteristics of the transition from natural philosopher to burgeoning scientist. Shelley's poem tells the story of an unnamed Poet who died without recognition for his life or work. However contested the meaning of this poem may be, what is clear is that the poem is about more than just a Poet; I argue that this Poet is also a burgeoning scientist on a quest to discover the secrets of nature. The character of the Poet embodies multiple traits that become critical to understanding what defined a scientist later in the century. The unwillingness of the Poet to recognize the limitations of his desire to discover the unknown results in an isolation from any sense of community, which ultimately leaves the Poet with a completely desolate life and solitary death.

Percy Shelley was infamous in his youth for experiments that often went wrong and caused explosions. Shelley's scientific endeavors, as Carol Grabo argues, were more than just a fleeting fancy, but rather deeply ingrained in his mind. "…books on alchemy, magic, Rosicrucianism; and, in science, Priestley's work on electricity, Erasmus Darwin's *Botanic Garden*, Newton's *Opticks* perhaps. These or similar works Shelley must have read at a very early age. His mind was colored by them, his imagination given its bent" (1). Thomas Jefferson Hogg, his closest friend at Oxford described Shelley's fascination with science saying he was, "passionately attached to the study of what used to be called the occult sciences, conjointly with that of the new wonders, which chemistry and natural philosophy [physical science] have displayed to us" (Hogg QTD in Nichols). Furthermore, Grabo argues that these works became influential and helped to define Shelley's adult philosophy, "The interest in science which held him to his Oxford days found no later expression in experimentation. But the teachings of science combine with Plato and the humanitarian French philosophers to compose Shelley's philosophy" (1-2). Even though Shelley did not pursue a career in science, there is no doubt that his fascination with science throughout his childhood and schooldays continued and was still present as he pursued his literary endeavors.

Shelley's childhood fascination with science grew into a continued intellectual pursuit as he regularly read the *Philosophical Transactions of the Royal Society* and debated about contemporary science with friends, even fellow members of the literary elite. Mary Shelley discusses one such debate as part of the inspiration for her novel *Frankenstein;* “Many and long were the conversations between Lord Byron and Shelley…They talked of the experiments of Dr. Darwin…who preserved a piece of vermicelli in a glass” (ix). Additionally, Shelley was introduced to many new theories and advancements in the sciences through Adam Walker. Fulford explains how “Walker lectured on astronomy, electricity, and magnetism, mediating the discoveries and theories of Humphry Davy, Erasmus Darwin, and Luigi Galvani to Percy” (170). Shelley was knowledgeable of contemporary science and well versed in different disciplines and thus it cannot be perceived that Shelley’s works were not influenced by his knowledge and interest in science. Shelley’s knowledge of science is important, but not inherently necessary to this study. What I mean here is that as long as we acknowledge the hybridity of literature and science, even if a poem or piece of writing is not specifically about science, it does not exclude the possibility that it can be influenced by or, in turn, influence science. Knowing Shelley’s background does not force a need for an agreement that his poem *Alastor* is directly intended to be about a scientist. What is important to recognize is that even traits not specifically addressed as scientific came to be influential in the development of the emerging scientist.

Shelley’s story moves beyond a traditional Romantic journey[7] and begins to set the tone for a more scientific quest as his own protagonist fails to make the final self

[7] Discussing the common motif of the journey in Romanticism finds its place in some of the foundational scholarship on the literature of the period; M.H. Abrams argues that the journey mimics the biblical story of the Prodigal Son, as a “pilgrimage and quest—the journey in search of an unknown or inexpressible something” (93). However, the journey usually brings the wanderer back to where he started. Abrams explains the significance of

realization of one's own limitations critical to the traditional Romantic quest. In the Preface, Shelley writes that the poem "represents a youth of uncorrupted feelings and adventurous genius led forth by an imagination inflamed and purified through familiarity with all that is excellent and majestic to the contemplation of the universe. He drinks deep of the fountains of knowledge, and is still insatiate" (72). Shelley's protagonist is moved to undertake a journey to try and pierce through the natural world and satisfy his desire for knowledge, which cannot be done without uncovering all that is hidden in nature, or beyond. Shelley makes a connection to the Faust legend with the Poet's desire for more than the world can offer and his inability to recognize the consequences of such a desire. And Faust is often considered a natural philosopher, or early proto-scientist. Shelley's Poet fails to acknowledge that as man he is bound to the "conditions of the finite world" and allows his "irresistible passion [to pursue] him to speedy ruin" (Shelley 73). His desire, his "dying to know" is characteristic of how a nineteenth-century scientist functioned, and aligns him with future Romantic depictions of the scientist such as Frankenstein.

As the poem, *Alastor; or, the Spirit of Solitude,* begins, the reader is introduced to the frame narrator, also a poet, worshipper of nature and thus, an aspiring scientist.

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the quest for something infinite, that the Romantic journey "is qualified by the realization that the goal is an infinite one which lies forever beyond the reach of man, whose possibilities are limited by the conditions of the finite world" (194). The Romantic journey, often considered an adaptation of the medieval quest, explained by Abrams and reiterated by other Romantic critics like Harold Bloom, focuses on the importance of growth through a turn inward and a realization of one's own powers. See Bloom's *Romanticism and Consciousness: Essays in Criticism* (New York: W.W. Norton and Company, 1970) for a discussion of the Romantic Quest as understood by foundational Romantic Scholarship.

Shelley's fascination with science finds itself materializing not only in the main character, but in the narrator as well. The narrator presents his love to nature and his dedication to understanding and pursuing its mysteries:

For I have loved
Thee ever, and thee only; I have watched
Thy shadow, and the darkness of thy steps
And my heart ever gazes on the depth
Of thy deep mysteries (19-23)

As Michal Ferber claims, "these and other details of the opening section seem to define the narrator as a nature-poet, bound by the natural world and more or less content to be so" (660). But these words also describe the narrator as a natural philosopher, a Romantic scientist, who has left the laboratory to discover the real mysteries of the natural world. The narrator explains that he

…ha[s] made [his] bed
In charnels and on coffins, where black death
Keeps record of trophies won from thee,
Hoping to still these obstinate questionings
Of thee and thine (23-27).

Describing how he has pursued dead matter in an attempt to understand life, the narrator aligns himself with the teachings of one of the most famous scientists of the time, Sir Humphry Davy. Davy claimed "the study of the simple and unvarying agencies of dead matter ought surely to precede investigations concerning the mysterious and complicated powers of life" (141). The narrator's discussion of his time spent in charnel houses aligns his studies with those of Romantic scientists. Shelley is clearly knowledgeable of contemporary studies in science as he creates a narrator who directly references the teachings of one of the most famous practitioner and lecturers of science during the

Romantic period. Displaying similar pursuits to scientist, the narrator is not simply just a nature-poet so common during the period, but is also a burgeoning scientist.

How the narrator compares himself to an alchemist, "like an inspired alchymist / staking his very life on some dark hope" further substantiates the argument that the narrator is actually a budding scientist (31-32). Alchemy, a practice associated with alchemical experiments that attempted to transform metals into gold and develop the elixir for life among others has ancient roots. However, alchemy provides more than a magical history of experimentation; alchemy is the basis for much of developing science. Stanton Linden, in his historical study of alchemy through the ages, argues for the value in including alchemy in understanding science when he says, "…the continuing reevaluation of the role of alchemy in the scientific thought of Robert Boyle and Isaac Newton, which has demonstrated conclusively that, much more than an early or casual interest, alchemy was at the heart of the thought and method of each of these pioneers of modern science" (1). The argument that alchemy plays a critical role in two of the most famous scientists in history helps to strengthen the connection that Shelley is making between the narrator, an "inspired alchymist", and science. Mary Shelley also bases Frankenstein's scientific pursuit in alchemy before he is convinced to switch to current modes of science thanks to his professors. Even without a historical perspective on the value of alchemy, alchemy is associated with experimentation, a practice undeniably linked to science.

As a developing scientist and poet, the narrator has staked his own life's journey on pursuing nature, "though ne'er yet / though has unveil'd thy inmost sanctuary" (37-38).

Though he has yet to be successful in unearthing the mysteries of nature, the narrator has dedicated himself to the quest. Shelley places his narrator in the middle of the vitalism debate that was dominating scientific discussion during the early nineteenth century (Holmes *Shelley* 313). Shelley was intimately knowledgeable of the vitalism debates through his close connection with William Lawrence, the doctor and essayist on evolutionary theory that took Shelley under his care (Holmes *Shelley* 286). Lawrence, a member of the Royal Society was controversial "because he chose to take issue with the views of those who 'suppose the structure of the body to contain an invisible matter or principle, by which it is put in motion'" (Jacyna). Lawrence was at the heart of the vitalism debates and exposed Shelley to some of the more controversial science of the time. Shelley specifically presents the narrator in search of the origins of life in nature, a reference to the vitalism conversations. The purposeful connection of the narrator by Shelley with the characteristics of the developing scientist is undeniable.

This initial discussion of the narrator's personal pursuits as a Romantic scientist likens him to the Poet who he spends the rest of the poem describing. The narrator discovers the Poet's unmarked and uncelebrated grave, providing a parallel for the reader to see between the narrator, a budding scientist still pursuing nature, and the Poet, also a Romantic scientist, whose pursuit of nature led to his solitary death. Shelley explains in the Preface, the Poet, the "adventurous genius" has a devastating end, one of self-sacrifice, as he continues to pursue his desire to breach the realm of the natural world (73). Shelley presents the initial introduction to the Poet through his neglected tomb, reinforcing the solitary and isolated life that the Poet ultimately led, even before his life is discussed. Furthermore, in the Preface, Shelley claims that the Poet "lived, he died, he sung, in solitude" (60). This repetitive reinforcement of the Poet's solitude even before the reader is introduced to his life, makes an important connection between the Poet and the perceived life of the solitary scientist.

The Poet is described as an intelligent and learned character who pursued knowledge, "the fountains of divine philosophy…he felt / and knew" (70, 74-75). But the knowledge that the Poet could gain from a book was not enough to satisfy his desire to know. The narrator describes how "when early youth had past, he left / his cold fireside and alienated home / to seek strange truths in undiscovered lands" (75-77). Travel was necessary for the Poet to discover the knowledge that he sought, to uncover and understand "strange truths" that only existed outside of what he knew, outside of his home. Beyond "strange truths" the narrator describes how specifically, "nature's most secret steps/ he like her shadow has pursued" (81-82). The Poet was on this journey to undiscovered lands with the purpose of understanding nature's secrets. He desired to understand the natural world, which defines him as a Romantic scientist aligned with pursuits of natural history.

Ever representative of the Romantic age was the unquenchable pursuit of knowledge, no success was enough and the desire to know went beyond the bounds of what was capable for the knower. Levine emphasizes this when he says, "dying is one consequence of the Faustian pact for knowledge, death both for the aspiring knower, and for the world in which things get known" (*Dying* 15). The Poet is described as having

> …ever gazed
> And gazed, till meaning on his vacant mind

Flashed like strong inspiration, and he saw
The thrilling secrets of the birth of time (125-128)

The Poet was determined to know that which he pursued, and he dedicated himself to something until, as the passage describes, the secrets of nature were revealed to him. However, this knowledge was not gained without sacrifice on behalf of the Poet. He has abandoned any form of real human companionship and community as he is described as "making the wild his home, / until the doves and squirrels would partake / from his innocuous hand" (99-101). Nahoko Alvey argues that "*Alastor* has been considered a typical example of a Romantic internalized quest, removed from reality to a lonely psychological realm" (56). But the Poet's quest is more than just internalized and typical. The physical nature of his isolation adds to the removal of the Poet from "reality". The journey, although clearly a psychological one, is also a physical one, which is important to acknowledge as one looks at the Poet next to the Romantic scientists that were so often on a literal quest to discover the unknown. The Poet's isolation was a result of his quest for knowledge and thus places him alongside the Romantic traveler and scientist that was burdened by the inevitable isolation of his pursuits.

Even when the Poet is around other humans, he keeps himself isolated and oblivious to the potential companionship they offer. The Arab Maiden that takes care of the Poet is in love with him and moved by his every need; yet, the Poet does not acknowledge that she exists, let alone that she could be a companion to him on his journey to knowledge (129-139). This is evidence of what Turner claims occurs with the Romantic traveler on a quest for knowledge; even when companions are around, the traveler ends up in a position of isolation (14). This isolation is seen with the Poet, specifically and most importantly in the moment with the real Arab Maiden. She desires to be his companion, but as he fails to notice her existence, he is left alone, once again. Shelley juxtaposes the scene of the real Arab Maiden with the vision of the dream maiden, whose imagined existence acts as the catalyst to the movements and quest that takes the Poet to the end of life. Morse Peckham claims that although "philosophically faulty" for the Romantics, "the notion that the task of science was to discover the laws of nature" ultimately led "to believe that the discovery of the laws of nature meant the unveiling of the mind of divinity itself" (*Romanticism* 39-40). The motivation to partake in scientific pursuits was to discover the secrets of nature, and as Peckham elucidates for many Romantics discovering the secrets of nature meant discovering the secrets of the divine or the supernatural. For Shelley's Poet, he is convinced his vision of a veiled maid meant she existed somewhere beyond the bounds of the natural world.

In the Poet's dream, a veiled maid is revealed to him. She is one that represents ideal love for the Poet. She has the same desires and pursuits as the Poet and the narrator explains how, "knowledge and truth and virtue were her theme" (158). Almost as quickly as she appears to the Poet in his dream, she vanishes as sleep takes over.

> And night
> Involved and swallowed up the vision; sleep,
> Like a dark flood suspended in its course,
> Rolled back its impulse on his vacant brain (188-191).

The Poet awakens from his vision with a changed purpose. His only goal, his only thought and desire was to find the veiled maid that revealed herself to him. This new quest for the ideal dream companion leads the Poet on a journey different from those he previously attempted. "He eagerly pursues / beyond the realms of dream that fleeting shade; / he overleaps the bounds"; the Poet desperately attempts to find where the veiled maid exists in his waking world, outside of sleep (205-207). He is convinced she was more than a figment of his imagination, and he is determined to seek her, and find the place where she and he can exist together in the real. If one could understand the natural completely, they would have the pathway to the supernatural, a world beyond the Poet's reality. Shelley's placement of the Poet on a quest for a world outside of his reality reinforces his connection with the characteristics of what became the cultural perception of the scientist in the nineteenth century.

The Poet's journey drastically changes while he is in pursuit of the veiled maid. The Poet will no longer be satisfied with his typical pursuit of seeking out nature's secrets, now his fulfillment revolves around discovering that which lies beyond; "This doubt with sudden tide flowed on his heart, / The insatiate hope which is awakened, stung/ his brain even like despair" (220-222). The Poet fears he will never locate the maid and now must pursue her to the end. The new pursuit takes a serious toll on the health of the Poet; "Shedding the mockery of his vital hues / upon his check of death" (238-239). The Poet is denying himself; and according to Levine, the Poet is acting in the typical fashion of a scientist. Displaying characteristics of the nineteenth century scientists, the Poet was "dying to know" in his pursuit to discover a place in which both he and the maid could exist; he sacrifices himself in the pursuit of the unknown (Levine).

The Poet pursues his desire outside of the natural realm of the human, "he sought in nature's dearest haunt, some bank, / her cradle and his sepulcher" (429-430). The narrator even describes that the Poet succeeded in reaching a place outside the human realm, where only “one step / one human step alone, has ever broken / the stillness of its solitude” but ultimately nature’s cradle is his own tomb (588-590). He finds the end of his journey without ever reaching the place of the veiled maid and trapped by the curse of the Romantic scientist, finds himself in a state of isolation alone and without human company, “But on his heart its solitude returned” (414). The Poet unlocked the secrets of nature, which fulfilled the dreams that first inspired him to travel beyond his home in pursuit of ultimately knowledge. Yet, he is unable to share that experience and knowledge with anyone as it has caused him to be completely separate from all other human contact. In his pursuit for the ultimate companion, the Poet loses his own humanity. There is something isolating about the quest to discover unknown secrets in nature that leaves a Romantic scientist secluded from any form of community regardless of the proximity to other humans. The secluded, isolated, and unstable state that the Poet finds himself in on his quest is a symptom of scientific discovery. Victor Frankenstein and Captain Walton also found themselves isolated even in the face of human companionship. Seeking the unknown often left a scientist alone and isolated, a characteristic one sees often in the scientists both fictional and real during the nineteenth century. Consider the unhappy and lonely nature of Herbert Spencer and Caroline Herschel in their old age as discussed in chapters one and two. Even given their numerous contributions to science, they were isolated and unable to truly share in or appreciate and recognize their contributions to the advancement of science.

Although the journey led the Poet to ultimate death, the narrator is moved by the story of the Poet and his life's journey, one that surpassed so many. The Poet—the Romantic scientist—leaves the narrator with

> Not sobs or groans
> The passionate tumult of a clinging hope
> But pale despair and cold tranquility,
> Nature's vast frame, the web of human things,
> Birth and the grave, that are not as they were. (716-720)

The narrator relates how things are "not as they were" and he is changed by the journey that the Poet made. That is the ultimate goal of the Romantic scientist, to pursue nature, to unveil the secrets hidden, and to be the first to gain that knowledge and share it with the world however dangerous the journey may be. At a time when scientific discoveries were constantly changing the understanding of existence, Shelley knowledgeable and moved by the debates of his time, presents a poem about a Poet, a Romantic scientist and leaves it to exist in a liminal space where the real meaning is constantly debated. As Ferber argues,

> Shelley did not, in the end, make it clear if we are to take *Alastor* as a skeptical dialogue or an anguished monologue…it seems wiser to allow that Shelley might not have sorted everything properly…Critics are always in search of a formula that would sublate, or simultaneously cancel and preserve at a high level…all the contradictions of a text. (662-663).

Regardless of what the Shelley's intentions were in the sense of a warning or meaning or caution of this poem, it is undeniably clear that Shelley presents not just the story of a traditional Romantic journey that leads back to its origins, as Abrams discussed, or the life of a simple nature-poet, but rather one who embodied the qualities and characteristics of the burgeoning scientist in the Romantic period, qualities that became essential to the development of the definitive scientist in the late nineteenth and early twentieth centuries.

Victorian Fictional Literary Depictions of Science and the Scientist

As science became more popular and intrinsically part of Victorian culture, it only makes sense that science would also become the subject of more and more literary texts. Ursula DeYoung argues in *A Vision of Modern Science* that the

> frequency with which the ['archetypal figure of the mad scientist torn between morality and the dangerous lure of scientific discovery'] shows up in fiction of this period demonstrates the ease with which authors adapted the traditions of gothic horror and ethical dilemma to the prevailing preoccupation with science. (209)

Even though science was becoming more professionalized into disciplines, the polymath poet-scientist was still present. As discussed in detail in chapter two, James Clerk Maxwell was not only a highly regarded physicist, but he was also a talented poet. He, like Erasmus Darwin, would try and capture scientific theory and engage with larger scientific questions in his poetry. But Erasmus Darwin was not the popular Darwin in the Victorian period. His grandson, Charles, stole the show with his *On the Origin of Species.* This text is full of literary techniques such as analogy and metaphor to explain his controversial theory. Darwin was also an avid reader and greatly enjoyed the novels of Jane Austen. Darwin's son Francis notes in letters how Darwin would read non-scientific works and enjoyed the pleasure of novels; specifically, he says, "Walter Scott, Miss Austen, and Mrs. Gaskell were read and reread until they could be read no more" (Qtd in

Bankes 1). Additionally, Gillian Beer explains that Milton was incredibly influential on Darwin during his voyage through the Galapagos Islands. Milton's reimagining of Genesis in *Paradise Lost* provided an idea and space through which Darwin could reimagine, based on his observations, a much different creation story that would lead to his momentous evolutionary theory (34-36). Darwin's reimagined world, made possible by literature, also resembles a type of thought experiment connecting him to Smith and Maxwell and establishing, once again, the importance of the imagination in science. Charles Dodgson was also a writer-scientist, who studied mathematics and logic, yet most would know him by his pen name Lewis Carroll. Carroll is well known for his fantasy stories including *Alice's Adventures in Wonderland* and *Through the Looking Glass*.

Similar to the Romantic period, Victorian fiction was filled with overt and direct references to science. In 1884, mathematician Edwin A. Abbott wrote the novella *Flatland. Flatland* is a science-fiction text that takes place in a two dimensional world, through which Abbott is able to satirize and thus critique the structure of Victorian society. Robert Louis Stevenson's text, *The Strange Case of Dr. Jekyll and Mr. Hyde*, uses science and a form of the mad scientist to confront questions of urban degeneration, a key discussion in the period. Bram Stoker's *Dracula* depicts a Victorian scientist through the character of Van Helsing, while also engaging directly with new theories of thermodynamics and energy science. Outside of science fiction, Arthur Conan Doyle's character Sherlock Holmes used logic and scientific reasoning to solve the many mysteries he was confronted with. Potentially the most infamous scientist character in the

Victorian period is H.G. Wells' Dr. Moreau from *The Island of Dr. Moreau.* As was the case with *Frankenstein*, this study would be heedless to not include a brief discussion of the science and scientist in Wells' story.

Yet as was the case with the Romantic period, there were numerous texts that were interwoven with an air of science and scientific theory in the Victorian period without directly confronting the issues. Thomas Hardy's novel *Jude the Obscure* clearly reflects the evolutionary idea of survival of the fittest in the life story of its main character. Additionally, many of George Eliot's grand novels incorporate aspects of scientific theory. *Middlemarch* in particular is a novel that engages with theories of evolution from the idea of slow time to the question of natural selection. Eliot connects theories of natural selection and survival of the fittest by engaging the idea of being most aptly suited for survival through one's own adaptations to the environment. For Eliot, the environment consisted much of the social environment of the rural town of Middlemarch. Her characters least able to adapt to the changing social and industrial world surrounding them were ultimately the least successful in the novel both in their own personal lives, and in a key factor of evolution—the ability to procreate and pass on their line. Typically not considered a novel focused on science or scientific themes, *The Picture of Dorian Gray* contributes to the cultural perception of the scientist because the plot of the novel revolves around a scientific experiment on the human psyche and its results. In chapter two, characteristics of a Victorian scientist were discussed and through those, there is an understanding that a Victorian scientist was a man of science bound to a different moral code that enforced objectivity and detachment as key features of a successful experiment and therefore necessary for results that could be understood and worthwhile to a universal group of people. Given this understanding, considering *The Picture of Dorian Gray* a science based novel that focuses around a single experiment conducted by a Victorian scientist (Lord Henry Wotton) on his human subject (Dorian Gray) becomes more understandable.

Close Readings of *The Picture of Dorian Gray* and *The Island of Dr. Moreau*

H.G. Wells produces *The Island of Dr. Moreau* in 1896. The 1859 publication of Charles Darwin's *On the Origin of Species* followed with *The Descent of Man* in 1871 provide a turning point in scientific theories relating to the workings of the body and the origins of life. At this time, there were also much more established standards for professionals of science. The plot of the story is based around Dr. Moreau's rejection from the scientific community. At one point a well-respected and dignified physiologist in England, Moreau became ostracized not only from his colleagues in the profession but also from society when the cruelty of his science was exposed. Wells explains how "A journalist obtained access to his laboratory…and by the help of an accident—if it was an accident—his gruesome pamphlet became notorious. On the day of its publication a wretched dog, flayed and otherwise mutilated, escaped from Moreau's house" (35). Moreau refused to detach himself from his hopes for the outcome of his experiment, and thus, as discussed in chapter two, he was not involved in a moral scientific pursuit.

The Island of Dr. Moreau introduces the reader to the world of vivisection as Dr. Moreau attempts to hasten the newly understood theory of the evolution of life, taking animals and trying forcibly to evolve them into rational men. Unlike the naive understandings of the origin of life put forth by earlier scientists, Moreau needs more than just a "spark" to produce man-like creatures. As Daniel Dinello aptly explains, "The tyrannical mad scientist Dr. Moreau employs advanced techniques of vivisection…to mold posthuman beast-men from apes, wolves, and pigs" (43). The research of scientists contemporary to Wells such as Claude Bernard, Charles Darwin, Thomas Huxley, and Sir James Paget shows that the experimental science of vivisection practiced on the Island is anything but fictional; rather, Wells bases the vivisection experiments documented in *The Island of Dr. Moreau* on the real science of these men. As Bernard, a leading scientist contemporary to Wells, describes in "An Introduction to the Study of Experimental Medicine – Vivisection", Vivisection, is a process needed to "succeed in learning the laws and properties of living matter" which can be obtained "only by displacing living organs in order to get to their inner environment…we must necessarily dissect living beings to uncover the inner or hidden parts of the organisms and see them work" (203). He explains further that

> A physiologist is not a man of fashion, he is a man of science, absorbed by the scientific idea which he pursues: he no longer hears the cry of animals...under the influence of scientific idea, he delightedly follows a nervous filament through stinking livid flesh, which to any other man would be an object of disgust and horror… (207)

Moreau embraces the philosophy of a vivisector presented by Bernard. In a conversation between Prendick, an uninvited visitor to the island, and Moreau, Prendick's disgust is expressed as Moreau attempts to explain his science; "I see you look horrified, yet I am telling you nothing new. It all lay in the surface of practical anatomy" (81). Just as Bernard explains, non-scientists like Prendick cannot see beyond the "cry of animals" but scientists, like Moreau, are completely devoid of any emotional tie to their experimental subjects (Bernard 207).

Moreover, Bernard, in terms of experimenting on live creatures, says, "No hesitation is possible; the science of life can be established only through experiment…it is essentially moral to make experiments on animals, even though painful and dangerous to him, if they be useful to man" (206). There can be no hesitation in such science and the possible end result, one that has the potential to benefit mankind, is worth the pain inflicted. Paget, in "Vivisection: Its Pains and Uses", reiterates this point by taking it one step further arguing that animals, those lesser than man, have a lesser sensitivity to pain, "so the pain inflicted by…a vivisector is certainly less than would be inflicted in a similar injury on any man" (211). Paget's research provides Moreau a justification for experimenting on live animals because the pain inflicted is much less than one would think. Moreau, along the lines of Paget, but even more extreme in his thoughts, believes that pain is "simply our intrinsic medical adviser to warn us and stimulate us," it is absolutely "needless" and he believes that "it's possible that such animals [the lower animals] do not feel pain" (84). Moreau uses his understanding of pain to erase any moral or ethical qualms that might arise with his style of experimentation through vivisection.

Moreau, having taken on the role of a god and assumed the power of nature does not hesitate to dominate all that is part of nature; "To this day I have never troubled about the ethics of the matter. The study of Nature makes a man at last as remorseless as Nature" (85). Jon Turney explains the position of Moreau in more detail in *Frankenstein's Footsteps* when he says, "The picture Wells draws of Moreau…is deliberately that of the modern scientist, stripped of all fellow-feeling for other creature, and of ethical qualms" (57). This description of the modern Victorian scientist results from the nineteenth century scientific understanding of the need for detachment and objectivity. If the experiment was pursuing a greater understanding that would have a benefit to all, then the potential consequences were worth the risk and therefore moral. The feelings expressed by Moreau, although frightening for a reader, are founded in the rationale of the scientific theory of the time even if they are taken to the extreme.

Bernard explains that "to learn how man and animals live, we cannot avoid seeing great numbers of them die, because the mechanisms of life can be unveiled and proved only by knowledge of the mechanisms of death" (204). Moreau shares these feelings and expresses to Prendick that through his experimentation, "some disagreeable things happened at first. I began with a sheep, and killed it after a day and a half by a slip of the scalpel; I took another sheep and made a thing of pain and fear…the more I looked at it the clumsier it seemed, until at last I put the monster out of its misery" (87). Vivisection is the means through which Moreau ultimately attempts his larger plan: he hopes to seize the power of nature to accelerate the advancement of the minds and bodies of irrational animals into rational men. He is using vivisection for more than prescribed by Bernard, he is not just trying to understand how living beings work, but more so, he using the science to transform, to progress and to evolve those beings.

Moreau explains to Prendick that he has not vivisected humans to make them animal-like, but rather the opposite: he has created men out of animals. Wells writes, "They were animals—humanised animals—triumphs of vivisection…'Monsters manufactured!' … 'Yes. These creatures you have seen are animals carven and wrought into new shapes" (80-1). In "On the Physical Basis of Life" Huxley explains

> there is some kind of matter which is common to all living beings, and that their endless diversities are bound together by a physical, as well as an ideal, unity…No very abstruse argumentation is needed, in the first place, to prove that the powers, or faculties, of all kinds of living matter, diverse as they may be in degree, are substantially similar in kind. (274)

This new understanding of the basis of life that Huxley articulates allows for Moreau to partake in his science. He can use the matter of animals to advance them to the matter of man because the living matter is "similar in kind" (274). Vivisection, combined with this understanding of matter, allows for Moreau to create man with matter that is still living—he can transform animal matter, advance it to be part of a man-like form.

The evolutionary theory Moreau was attempting to quicken focused on the idea of natural selection put forth by Darwin in *On the Origin of Species,* which answers the question of how the variability in species and life has occurred on the planet.

> How do those groups of species…arise? All these results…follow inevitably from the struggle for life. Owing to this struggle for life, any variation, however slight and from whatever cause proceeding, if it be in any degree profitable to an individual of any species…will tend to the preservation of that individual, and will generally be inherited by its offspring. The offspring, also, will thus have a better chance of surviving…I have called this principle, by which each slight variation, if useful, is preserved, by the term of Natural Selection. (258-59)

Darwin's evolutionary theory provides plausibility to the science of Moreau, and Moreau's interests are in speeding up the process that Darwin explains. The process of

Natural Selection takes millennia, and that time constraint is essentially what Moreau is trying to remove in his experiments with vivisection and man making. If he can advance the state of the animal, to one that is rational and resembling man, he then successfully will have sped up the process of evolution. And with natural selection, if he is successful, these rational traits, now part of the one-time animal, will be passed on to the progeny and continue to evolve into a species of higher beings like humans. Moreau's altered beast folk occasionally did procreate "but these generally died. When they lived, Moreau took them and stamped the human form upon them. There was no evidence of the inheritance of their acquired human characteristics" (Wells 150). Moreau's science fails again as he follows a more Lamarckian[8] understanding of evolution even though he attempts to use Darwin's theories to supplement his knowledge. Moreau's isolation and lack of communication with a scientific community is in great part responsible for his failed science as he is unaware of the gaps in his understanding of the scientific theory he is attempting to use. As we see through the experiments, the "possibilities of vivisection", for Moreau, "do not stop at a mere physical metamorphosis"; he is interested in the advancement of their brain power, their ability to be rational creatures, like man both in form and thought (82). Moreau's failed science in part is due to his exclusion from the scientific community. This shows how important the social nature of science was, which

[8] Prior to Darwin, Lamarck's evolutionary theory was widely accepted. Adaptation, for Lamarck, was brought about by a change in environment and thus a change in an organic response to the environment and these changes would be passed on to the progeny. Many use the giraffe example to explain Lamarck: the more a giraffe needed to extend its neck to reach the leaves on the tree, the longer the neck would be and that adaptation would be passed on to the offspring (Gould 178-179).

included the responsibility of a scientist to have their work evaluated by others in order to be deemed significant. For example, as described in chapter two, critical to Caroline Herschel's discovery was the ability for another to evaluate and verify her work. Additionally, the lack of experimental proof to substantiate Maxwell's theories early on led to many thinking his work was fanciful. Moreau's lack of verification by the scientific community contributes to his failings as part of the scientific community.

Moreau is successful in his ability to advance the minds of animals to those of rational beings immediately after he completes his work on the animal, as he says, "these creatures of mine seemed strange and uncanny to you as soon as you began to observe them, but to me, just after I make them, they seem to be indisputable human beings" (89). Without the scientific theories put forth by Bernard, Darwin, Huxley, and Paget, Moreau's attempts at creating such beings would be completely farcical; yet, even in fiction, his advanced scientific knowledge is clearly laid out for the reader to understand, grasp, and terrifyingly enough, find plausible. The inclusion of real scientific techniques and theory, even if misunderstood by the character, provides the audience with a more haunting presentation of the scientist because of the potential, even in the slightest, for a scientist to really be like Moreau. Like Shelley, Wells' depiction of a scientist cautions society of the importance of the scientific community and the social nature of scientific pursuit that is necessary for successful science.

The Island of Dr. Moreau establishes its rightful place in the long history of science-fiction texts that question the role of the mad scientist. Dr. Moreau, like Victor Frankenstein, provides no question that ethical bounds were crossed in his very descriptive and detailed science. Similarly, *The Picture of Dorian Gray* presents a Victorian scientist who breaks the ethical bounds of objectivity resulting in disaster. Critically, *The Picture of Dorian Gray* is discussed for its focus on the development of the aesthete in society and the aestheticism that permeated the decadent lifestyle of Wilde-esque characters in late Victorian culture. The focus on aestheticism in much of the commentary is not as far from viewing the novel through a scientific lens as one might think; on the contrary, the connection between the aesthetic and scientific lifestyle is quite similar and provides a bridge to reading the novel for its scientific commentary. Kanarakis Yannis argues in "The Aesthete as a Scientist" through his discussion of Walter Pater that aestheticism and empiricism are both utilized in a "pursuit of knowledge, precisely because of the structural kinship between art and science, which was the theoretical device through which he was able to convert scientific tenets into aesthetic ideals" (97). In *The Renaissance,* Pater's description of Leonardo da Vinci working on his paintings is just the way one would describe a scientist pursuing an experiment:

> Poring over his crucibles, making experiments with colour, trying, by a strange variation of the alchemist's dream, to discover the secret, not of an elixir to make man's natural life immortal, but of giving immortality to the subtlest and most delicate effects of painting, he seemed to them rather the sorcerer or the magician, possessed of curious secrets and a hidden knowledge, living in a world of which he alone possessed the key. (68)

The pursuit of da Vinci is described in the same language as a scientist pursues nature's secrets. Pater is emphasizing the connection between aestheticism and science. Similar to Yannis' argument, Levine describes aestheticism as "an austere, rigorous restraint of the self that, from the basis of an inevitable subjectivity, issued in an impersonality that opened both to art and to truth" (249). Yannis describes Levine as "establishing the impersonal objective vigour of the scientific in both art and science" (97). Yannis and Levine both expound on the similarities between the aesthetic tradition and the scientific tradition that make the connection between art and science so strong. This connection that is significant to the critical understanding of the scientific themes in *The Picture of Dorian Gray.*

Beyond the connection between aestheticism and science, Wilde includes numerous mentions of science or scientific themes throughout the novel, which include a direct reference to a Victorian scientist. With the prominence of science mentioned in the novel, one would be hard pressed to argue that science was not of particular importance to the overall development of the characters and plot. Furthermore, Yannis claims "nineteenth-century science and aestheticism were thus allied in their mutual appeal to freedom from social restraints and their common fight against traditional morals" (92). In the novel, Dorian Gray relies on a scientist, Alan Campbell, to clean up the dead body of Basil Hallward after Dorian kills him. Without the scientist Alan Campbell, Dorian Gray would not have been able to dispose of the body. The narrator describes Campbell as a person interested in science, "his dominant intellectual passion was for science…he was still devoted to his study of chemistry, and had a laboratory of his own, in which he used to shut himself up all day long" (Wilde 213). His knowledge of chemistry is what draws Dorian to approach Campbell. Dorian says, "Alan, you are scientific. You know about chemistry and things of that kind. You have made experiments" (Wilde 216). Campbell is a scientist, one that pursues the secrets of nature even if it brings him to "hospitals and dead-houses"; his ability to be unaffected by the horrors of nature helps to solidify his role as a scientist (Wilde 218). Bernard describes how a "man of science…delightedly follows a nervous filament through stinking livid flesh, which to any other man would be an object of disgust and horror" (207). A scientist is not affected by the same horrors as a non-scientist when the pursuit of knowledge and experiment is underway. Dorian uses this knowledge of science to his advantage in entrapping Campbell to help him. Dorian says to Campbell, "All I ask of you is to perform a certain scientific experiment" (Wilde 218). Dorian is playing on Campbell's devotion to scientific pursuits in arguing that he is okay to dispose of the body if he only considers it a "certain scientific experiment" (Wilde 218). Yet Campbell, a true scientist, rejects Dorian's pleas as they go against his ethical responsibilities because he recognizes the "experiment" is not for the betterment of humanity and only succumbs to acquiescing to take part when threatened by Dorian. Campbell's repugnance to Dorian's request solidifies not only his role as a Victorian scientist because he refuses to acknowledge any universal good in the experiment, but it also reinforces the necessary morality for someone to be considered a nineteenth century scientist.

Further examples of science in the novel arise when Dorian expresses his own desire to understand the scientific more as he muses about the composition of the painting. The narrator describes Dorian as "gazing at the portrait with a feeling of almost scientific interest…was there some subtle affinity between the chemical atoms that shaped themselves into form and colour on the canvas and the soul that was within him?" (Wilde 125). Similarly, on a separate occasion where Dorian views the portrait, he contemplates science: “Might there not be some curious scientific reason for it all? If thought could exercise its influence upon a living organism, might not thought exercise its influence on dead and inorganic things?” (Wilde 135). Dorian relies on his small understanding of science to attempt to understand the painting. He uses science as a way to explain the nature of his existence, an endeavor fundamentally sound with the purposes of any scientific pursuit. Dorian may not have been ascribing to the methodologies of science including objectivity and detachment, but through this reference, it is clear that Wilde still acknowledges that the ultimate goal of science was to “explain the natural world” (De Young 217). Therefore, this example solidifies the connection between Dorian’s musings and the purpose of science in the nineteenth century, acknowledging science as having an important role and authority in understanding the world.

The most significant and thorough application of science and scientific themes however in the novel are not based around a specific event like Alan Campbell or Dorian’s attempt to understand the nature of the painting. Rather, Lord Henry Wotton conducts a scientific experiment that permeates and influences every aspect of the plot. Caroline Levine in *The Serious Pleasures of Suspense* adheres to this argument as she says

> experimentation is also an explicit theme in the novel. Lord Henry Wotton sees Dorian as a perfect experimental subject…in this light, we could read the entire noel as an unfolding of Lord Henry’s experiment: it is under the sway of Lord Henry’s theories, after all, that Dorian first utters his wish to switch places with the portrait. (193)

Lord Henry’s scientific pursuits result in the Dorian Gray that defines the story.

Critics may argue that Lord Henry Wotton was a socialite, not a scientist; yet, beyond the professionalization of scientists in laboratories, the popularity of science amongst the people grew and developed a subset of "popular scientists". De Young argues that the scientists who did not devote their entire careers to the sciences, yet still pursued knowledge through experimentation, "used science as sounding board, punching bad, triumphal flag, or cultural litmus paper depending on their ideas and inclinations" (212). Following the idea of the popular scientist, it becomes undeniable that Lord Henry Wotton was, in fact, a scientist. Lord Henry states early on that he is "quite content with philosophic contemplation. But, as the nineteenth century has gone bankrupt through an over-expenditure of sympathy, I would suggest that we should appeal to science to put us straight. The advantages of science is that it's not emotional" (Wilde 57). Lord Henry was not hiding his desire to pursue science and openly discussed his interests in scientific pursuits amongst his friends. He had "always been enthralled by the methods of natural science, but the ordinary subject matter of that science had seemed to him trivial and of no import. And so he had begun by vivisecting himself, as he had ended by vivisecting others. Human life—that appeared to him the one thing worth investigating" (Wilde 77). Clear through this description by the narrator is that Dorian was not Lord Henry's first subject for experimentation. In the nineteenth century scientific community, the change from just the natural world as worth investigating to science investigating the human was seen not only in the development of psychology but also through the century's premier scientist, Darwin. Darwin transitioned his evolutionary theory to directly focus on the human in *The Descent of Man.*

Psychology became a separate scientific field of study in the second half of the nineteenth century, which is owed in some part to the psychologist Wilhelm Wundt who argued in his book *Principles of Physical Psychology* in 1874 for the "establishment of psychology as an independent experimental science" (Singh 95). Further evidence that in the nineteenth century psychology was considered its own branch of science with scientists, not just philosophers, conducting experiments is provided through the opening of the first psychology laboratory by Wundt at the University of Leipzig in 1879 (Hergenhahn 354). Wundt's Experimental Psychology aimed "to apply the experimental methods of natural science (particularly the physiology of Helmholtz) to essentially philosophical problems concerning the nature of the mind" (Thomas 1). Wundt's desire to align psychology with the sciences is evident beyond the need for a laboratory, but through his methodology and practices as well. Additionally, "later psychologists remembered him chiefly for his organization and promotion of laboratory studies" reinforcing his role as a key Victorian scientist (Danziger 72). Wilde's knowledge and awareness of current scientific trends, which are reflected in the novel is again a comment on the importance and purposefulness of the science and scientific themes of *The Picture of Dorian Gray.* Basil Hallward created the painting of Dorian Gray, which is significant for the main theme in the novel. However, arguably equally important is the creating role of Lord Henry. John Riquelme attempts to explain this relationship, "Hallward and Wotton split up the dual role that Leonardo da Vinci fills as the quintessential artist-scientist. As a detached experimenter with human lives, Wotton is an avatar of Victor Frankenstein" (616). Regardless of how many previous humans Lord

Henry attempted to influence and experiment on, clear from the first meeting between Lord Henry and Dorian is that Dorian represented the perfect subject for his scientific pursuit.

Before Lord Henry meets Dorian for the first time, Basil worries that his tendency to influence will have a detrimental affect on the pure and innocent Dorian, “Don’t spoil him. Don’t try to influence him. Your influence would be bad” (Wilde 23-24). Lord Henry, ignoring Basil’s pleas, begins to imbue Dorian with his tenets on aesthetic life, commencing his experiment during their first meeting. Lord Henry acknowledged his ability to influence Dorian as the narrator explains, “With his subtle smile, Lord Henry watched him. He knew the precise psychological moment when to say nothing” (Wilde 31). Lord Henry completely enrolls in the mode of a scientist as he disregards Basil’s concern for the detriment that such influence might have; he is detached and objective not allowing his personal or other’s concerns to affect his experiment. Raby argues, “by repeatedly encouraging Dorian to court new impressions, Lord Henry dangerously remains—as Wilde himself remarked—a “spectator of life,” disregarding the moral consequences of the influence of his exercises” (213). Lord Henry, by disregarding the potential immoral nature of his experiment, is acting as though he is a detached and objective scientific observer. However, as chapter two discussed, there was an inherent necessity for a morality present in the scientific pursuits of a Victorian scientist. As long as one’s pursuit is for a universal good, it is judged worthwhile—Lord Henry fails to establish that potential good with his experiment. However, as long as Lord Henry continues to believe there is a universal purpose, he continues to attempt to partake in the methodologies of detachment for the Victorian scientist.

Lord Henry appears to be unaware of the boundaries he is crossing, and his transgressions are there for the reader to recognize even though Lord Henry will continue in his role of scientist. The potential moral consequences of Lord Henry's experiment played no role in his consideration of his job as scientist, a spectator both objective and detached from moral consequences. The consequences of any experiment though, as Morse Peckham explains in *Explanation and Power* "are invariably in part unpredicted and unpredictable and, therefore, uncontrollable" (149). This idea that there is no way to fully know and comprehend the potential outcome of the experiment allows a scientist to remain objective and detached; the scientist can remain unconcerned about the potential outcome because there is no way for a scientist to truly know. His concern should be with the experiment, not the potential results; therefore, Lord Henry continues his experiment filling Dorian's mind with his philosophy.

Interestingly, Dorian acknowledges the hold that Lord Henry has on him and admits that he is enthralled with Lord Henry more than any other. He claims that Lord Henry "seemed to have disclosed to him life's mystery" (Wilde 33). Even with Dorian's acknowledgement of the important role Lord Henry played in his life, he does not resist any information he provides. The youth's naïveté blinds him to the fact that he is merely an experiment for Lord Henry. Lord Henry's motivation for experimenting on Dorian Gray is purely out of a curious fascination with understanding the workings of man, specifically the psyche. Lord Henry repeatedly refers to Dorian as fascinating and interesting throughout the novel, and as Dorian noticeably embraced his creator's philosophy, Lord Henry imparted more and more of it (Wilde 34).

Lord Henry desired in his scientific endeavor to see a man who lived a purely aesthetic lifestyle. Andrew Smith in *Victorian Demons* contends that "Dorian is molded from Lord Henry's philosophy of the self" and is merely "exists as a product" of that philosophy (173,170). Lord Henry claims that speaking to Dorian "was like playing upon an exquisite violin. He answered to every touch and thrill of the bow…there was something terribly enthralling in the exercise of influence" (Wilde 51). Although Lord Henry gains pleasure from the experiment, he still believes he is acting as a Victorian scientist should—objective and detached when it comes to the outcomes, which is a necessity for the Victorian scientist. Still, ultimately, the fact that Lord Henry does have an emotional connection to the experiment is evident of a larger commentary from Wilde about the real possibility, or rather impossibility of true scientific detachment. This questioning of the reality of complete objectivity and detachment, shown through the scientist of Lord Henry, is in alignment with much of the modern criticism about the Victorian scientific methodologies. But as Anderson argues in the *Powers of Distance,* just because true objectivity and detachment is not possible, the goals set out by the nineteenth century scientists with detachment—the goals of bettering humanity are not undermined or devalued (6). Anderson describes how Wilde attaches himself to a slightly altered form of detachments, a "cultivated detachment…that comprises both reflective distance…and freedom from constraints or limits" (152). As seen through the novel, Lord Henry attempts, regardless of ultimate success, a cultivated detachment.

Lord Henry was purposeful in his experimentation with Dorian Gray. He saw that Dorian "could be fashioned into a marvelous type" and with this experiment, his goal was to "dominate him…he would make that wonderful spirit his own" (Wilde 52). Lord Henry wanted power over his experiment and was able to use his knowledge of science in order to apply such power. For Lord Henry, "it was clear to him that the experimental method was the only method by which one could arrive at any scientific analysis of the passions; and certainly Dorian Gray was a subject made to his hand, and seemed to promise rich and fruitful results" (Wilde 79). Alongside the Victorian scientists of the time, Lord Henry embraced the idea of a detached observation in his experimentation on human life. Although Lord Henry was clearly involved in Dorian's life, he was detached from any feelings of guilt or remorse about the results of his experiment. Lord Henry claims that this type of investigation, one on human life, was worth investigating and even asked, "what matter what the cost was?" (Wilde 78). This lack of concern on the potential cost in terms of moral affect or the destruction of his object of experiment aligns him with the science of the day: as long as the overall goal was "to seek the truth even when it threatens to produce unpleasant results" (Levine 4). Yet what fails to ever be established is the greater good that Lord Henry's experiment hopes to bring to light. Lord Henry is overtly attempting to ascribe to all the tenets of a Victorian scientist but fails to uphold the necessary morality required by the profession in the nineteenth century. Anderson argues that although Wilde embraced cultivated detachment, "as *The Picture of Dorian Gray* attests, Wilde also holds a notion of seduction as sinister, surreptitious influence, especially of one personality by a powerful other" (164). Wilde is obviously using Lord Henry to question and comment on the possibility of true detachment as well as to show what happens when the scientific methods are taken too far. Therefore, the reader continues to witness Lord Henry embracing the motif of the Victorian scientist for the purpose of proposing questions about the progress and productivity of science.

Lord Henry's lack of care for the potential consequences of experiment are caused by his ability to see the potential if he is successful in unlocking the passions that make up the human psyche. Porter explains how the scientist "claimed a special authority for the trained man of science, whose access to deeper truth entitled him to an almost priestly status" (317). Lord Henry subscribes to this belief as he discusses how "ordinary people waited till life disclosed to them its secrets, but to the few, to the elect, the mysteries of life were revealed before the veil was drawn away" (Wilde 78). Lord Henry held himself up to be one of the elect who, through scientific experimentation, would be able to reveal the mysteries of life. He was not bound by the same moral code as others in society when he was in pursuit of such goals.

The more Dorian embraced Lord Henry's philosophy, the more he fell down the dark path of moral deprivation. However, Lord Henry remained by Dorian's side in order to continue gathering information and data from his experiment. As other members of the social community started to stay clear of Dorian, Lord Henry continued to accompany him at social gatherings. Lord Henry was completely detached from the dark discussions of Dorian's questionable behavior. He would not allow himself to be influenced by opinions or feelings; he was an objective scientist conducting an experiment.

Towards the end of the novel, Dorian begins to become aware of the terrible person he has transformed into when James Vane, the brother of Dorian's first victim, Sybil Vane, visits him. The narrator explains how "upstairs in his own room, Dorian Gray was lying on the sofa, with terror in every tingling fibre of his body. Life had suddenly become too hideous a burden for him to bear" (Wilde 264). Dorian is distraught with his actions and the result of his lifestyle and determines to change, "For I have a new ideal Harry, I am going to alter" (Wilde 268). Lord Henry, determined to see his experiment through to the end, attempts to continue his influence over Dorian, "'There is no use in telling me that you are going to be good' cried Lord Henry…'You are quite perfect. Pray, don't change'" (Wilde 268). Lord Henry wants Dorian to continue his purely passionate and aesthetic lifestyle in order to see the full results of the experiment. If Dorian repents and alters his existence, then Lord Henry will not fully be able to learn and know about the human psyche, as was his goal with this experiment. Furthermore, ascribing to be a detached and objective scientist, Lord Henry refuses, or acts as though he refuses, to believe the horrors that Dorian claims to have committed in order to further establish his objectivity and credibility as a scientist. He does not allow himself to be influenced by alleged crimes that Dorian admits to partaking in as it would hinder his objectivity. When Dorian suggests that he could have murdered Basil, Lord Henry replies, "All crime is vulgar, just as vulgarity is crime. It is not in you, Dorian, to commit a murder" (Wilde 273). Lord Henry is completely disconnected with the reality of what Dorian's life has become because he believes he has maintained his complete detachment and objectivity. Again, as Peckham describes, there was no way for Lord

Henry to truly predict the potential outcomes of the experiment with any level of certainty. Innately part of scientific endeavors is that consequences are "unpredictable and, therefore, uncontrollable" (Peckham *Explanation* 149).

The unknowable potential consequences of experimentation seem less severe when a scientist is conducting an experiment on a plant; however, as science transitioned into attempting to explain the nature of the human, there were more severe results with a much more serious impact. Dorian, the object of the experiment, becomes incapable of dealing with the reality of what his life had become; he stabs the portrait and thus ends his life. The death of Dorian, the final unknowable consequence of Lord Henry's experiment, provides a serious commentary on the potential hazards of living a lifestyle in full compliance with aesthetics without any attention to social conventions or standards. However, the outlook for science is not nearly as grim. For as Levine argues, "Lord Henry manages to survive the experiment because he insists on the distancing and detachment requisite for accurate observation" (*Darwin* 224). Lord Henry succeeded to the end in remaining as detached from the experiment as possible and therefore did not meet the same end as Dorian. However, the reader is still exposed to the potential consequences of the unbridled nature and impossible reality of complete detachment by the scientist.

Oscar Wilde's *A Picture of Dorian Gray* is much more than a novel discussing the ideal facets of aestheticism and the decadent movement. The novel is more than a scary tale of the consequences of behavior deprived of all moral or ethical concern. The novel questions the aestheticism and immorality, but it does so through the web of a scientific experiment, one that functions as a catalyst for much of the plot in the narrative. There would be no Dorian enraptured by his own beautiful image, declining into the depths of the darkest part of the human condition without the scientist who initiates the experiment on the human passions. Lord Henry Wotton is the catalyst and creator. Lord Henry Wotton, like Victor Frankenstein, The Poet, and Dr. Moreau, is a scientist embracing the methods and scientific knowledge of his time. Victorian science relied on the objective and detached observer in order to gain conclusions that would divulge nature's hidden truths. Lord Henry Wotton engaged in the essential characteristics of a Victorian scientist in order to conduct an experiment opening up the inner workings of the human mind to the outer world; he engaged in the practice of metaphorically vivisecting the human mind in order to gain a larger understanding about the human psyche. Smith argues that we can see "Lord Henry's influence over Dorian as an echo of that between Victor Frankenstein and the creature" (*Victorian* 172). Undeniably, *The Picture of Dorian Gray* is infused with scientific references and themes, but science plays more than just a minor role in this novel. Science is the foundation for which every aspect of the narrative comes to life, and therefore, *The Picture of Dorian Gray* occupies an important place in understanding the role of fictional depictions of the scientist on the cultural perception of science and the scientist in the nineteenth century. Thus, re-establishing the importance of this collective in the greater science network.

In *Consilience*, E.O. Wilson claims that Romanticists to Postmodernists, those engaged with fiction in an attempt to reconcile and understand the world, are menaces to reason and therefore separate from science and the scientists (45-47). Even if this were the case, which many scholars, including myself have argued against, Romantic and Victorian writers that are featured in this chapter still had an effect on and became part of the larger science network when they engaged with scientific theories and thoughts surrounding the advancement of science during their time. Many of the writers discussed would in fact qualify as scientists, even by today's more stringent standards. Their evaluations and discussions are a critical part of how science formed, in a cultural sense, and the scientist is very much a cultural phenomenon. The way Mary Shelley and H.G. Wells so carefully describe and include accurate scientific theories and techniques is an important way that the public was exposed to these sciences. Both texts were highly popular and those readers who did not engage with scientific theory would be exposed to the science of their time, even if fictionalized to a point, through these novels. Additionally, the underlying and obvious tones that permeate the writings of Percy Shelley and Oscar Wilde are also highly critical to the public's understanding of the role of science and the scientist in society.

What one finds through this investigation into these characters is that what has been discovered to be central to defining the characteristics necessary for a successful scientist in the nineteenth century through the earlier chapters, are exactly the characteristics that these fictional depictions lack. All four highlighted in this investigation cannot separate themselves from their extreme personal desire to achieve a certain outcome. Even if Lord Henry Wotton pretends he is objective, he has not alienated his pursuits from his personal desires and therefore lacks the moral and ethical objectivity required by Victorian scientists. Additionally, this project as a whole has shown the importance of the social and community aspect of scientific pursuits. Again, what one finds with these fictional characters is that they alienate themselves from the scientific community who may have been able to help them or keep them on track through communication and discourse. The fictional literary characters embody the fears of what happens when one strays from the established community that upholds a level of scientific ethics. These fears were inherent to the cultural perception of the scientist as they still are today. To ignore or write off the fictional contributions to the science network is unenlightened because one then fails to clearly and accurately discuss science and the scientist in the nineteenth century and beyond.

CONCLUSION

The purpose of this investigation was to highlight the different actors in the science network in order to unveil the influencers that affected the understanding of the scientist. Much of the previous scholarship looks individually at one of the collectives investigated here. Each collective offers much to the understanding of science and the scientist in the nineteenth century. The in depth and detailed analyses of individual collectives is necessary. But it is also necessary to acknowledge that those are individual and narrow investigations, and do not provide a picture of science in the nineteenth century. By only looking at a single collective, one fails to see a more comprehensive view, a view that acknowledges the multitudes of influences on the perception of science and the scientist in the nineteenth century. This project has moved beyond the narrow scope of much of the scholarship by introducing the reader to key collectives that were part of the nineteenth century science network and, more importantly, how those collectives together influenced the perceptions of science and the scientist. Together, through the chapters of each collective, one has a much more complete idea of how science functioned throughout Britain and who was involved in science.

Throughout this investigation of multiple collectives in the science network, one thing has been made particularly clear. As I argued the goal of this project was to fill a hole in scholarship in the introduction, I quickly found there are more and more holes that need filling. Particularly, there is a dearth of information on female science writers and popularizers and their roles and interaction with the other influencers and collectives part of the science network in the nineteenth century. There is a lot of research on the professionals of science and particularly the more famous members of the scientific societies and clubs during the period. But there is a need for more work to be done on the collective of female popularizers. I hope moving out of this project to complete a closer analysis on the individual collective of female popularizers. This in no way, then, is an argument opposite to what I have been working towards with this project. Each collective needs investigation and research to be done, but when one looks at science, one cannot only look at an individual collective. By increasing the scholarship on female popularizers, one will be able to get a more complete picture of their influence, and thus of their role as part of the science network. Additionally, through investigating these collectives, it also becomes clear that there are numerous additional networks or collectives that are part of and influence the science network in the nineteenth century that would be key to analyze and include in a much larger project.

This volume presents four key collectives of the science network; yet, this investigation is in no way completely comprehensive, the scope of a comprehensive investigation on the science network of nineteenth century Britain is infinite. One could easily devote a volume to each chapter, and still not be complete. But it is a start, and it, at the very least, provides a more complete picture of the science network to the reader. This volume forces one to acknowledge multiple influences on science when trying to understand the emerging scientist. And this is a move forward in scholarship on science in the nineteenth century. Science does not exist in a vacuum and it is not immune to the influences outside the towers of institutions. Science and the humanities are not truly separate nor are they two cultures because they are interwoven in the web of the science network.

Latour's insistence on the necessity and existence of hybrids helps to ease the understanding of the scientist in the nineteenth century. The scientist was literally a hybrid phenomena influenced by a wide range of actors and networks. I have presented science as a vast network comprised of collectives and focused specifically on four collectives during the nineteenth century. But what I have come to acknowledge through this investigation is the nature of the collectives. Each collective is, in a sense, its own sub-network of the larger science network during the period. Recognizing the multitude of actors within each sub-network and their differences helps to continue to recognize the intensely rich nature of science at the time. Investigating each sub-network also will allow an uncovering of more branches and diversity that operate as actors of influence in the greater science network of the nineteenth century. The work of Foucault is also useful here with the method he presents in *Archaeology of Knowledge* because he presents a method in which the discourse of these collectives can be peeled away in an archaeological approach to provide a more clear understanding of the cultural construction of science and the scientist during the nineteenth century (Kelly).

For example, chapter three focused on female popularizers of science during the period. Jane Marcet was a pioneer for women writers of science because she actually produced texts that were accurate and could help an uninformed reader learn about real science. But Marcet stayed in the place relegated for women writers, which was focused on providing women and children an introduction to science. She did not pursue any of her own inquiries into scientific work, nor did she suggest to other professionals how to perfect their work. Less than 100 years later, Agnes Clerke was recognized not only as a popularizer of science, but a historian of astronomy. She never would have achieved the position she did of respect within the astronomical community without the female popularizers who came before her. However, the vast difference between these women shows the complexity of the collective--and ushers in the need to recognize each collective as its own unique sub-network within the larger network of science.

The role of the popularizers of science was key in understanding the science network of the nineteenth century because they were responsible for how much of the actual science reached the minds of the public. The gaining popularity of the field, resulted in more pursuit of science, which helped grow disciplines and create a more expansive and authoritative body of science as we think of today and female writers had a unique role in that growth. Some might claim that they were not actual scientists and therefore not part of the science network, but as this investigation has shown, there is no real ground for that. This is especially the case when we look back to Clerke who did actually help change and improve the field of astronomy. And even when the writers were themselves not scientists, they still changed the way that the public perceived the scientist, by creating an entirely new population of science minded individuals, many of which would pursue careers as professional scientists. Science did not only grow as a field with new disciplines during the century, but its popularity also grew. Much of the reason for the popularity growth was due to a demand from the public for scientific information. This demand was a result of the changing nature of science and the idea that a person of science could be anyone. By bringing science to the public, the public became part of the face of science. The role of bringing science to the public was unique and held by popularizers. However, the practitioners of science early in the century also helped bring the excitement of science to the public through lectures and demonstrations.

The public lectures and demonstrations were not solely to provide entertainment to the public. As science became more sophisticated, a desire grew to professionalize science and garner a level of respect and authority for practitioners of science from the public. One way to grow in popularity and respect was through having a face in the public sphere. There was also a desire within the field to formalize science, in part because it was necessary to gain the respect that many hoped for from the greater cultural community. Rules and methods became part of the requirements for someone to be considered a scientist. Maxwell, like the Herschels, shows that scientists were all different kinds of individuals. Quirky and imaginative physicists, quiet and lonely astronomers, and outrageous and charming chemists were all scientists. There was no one clear definitive role of a scientist.

As science grew and expanded, so too did the perception of the scientist. One also sees that the social nature of science was incredibly important to scientific advancement at the time. The ability to exchange ideas, even absurd ideas about lassoing the polar ice caps to help create more moderate environments, allowed for a dialogue and conversation that often led to inspiration. The social nature of the societies and the members of such societies changed the way one looked at a man of science. The members of these organizations, due to the changing nature of science and society, were not the elite from

Cambridge and Oxford that once made up the scope of a man of science. Many of these individuals were middle class tradesmen. A scientist, did not need to be a Cambridge man to have an influence in the field. A man of science, a scientist, was not locked away hidden in the ivory tower, he was gathering over dinner with friends to discuss his next crazy idea. He was exchanging notes about experiments and requesting advice from a friend about how to move forward. A scientist was a person, not just a man as demonstrated by Caroline Herschel, pursuing scientific advancement regardless of background, education, sex or class.

Public lectures and popular science texts were not the only way that the public was exposed to the growing and advancing science of the nineteenth century. Fictional depictions of the scientist ranged from cartoons included in periodicals, to depictions in art such as with Joseph Wright of Derby, to depictions of science and the scientist in poetry and novels. As is often the case with fiction, the depictions of science and the scientist were extreme and often stretched reality. Think about Dr. Moreau. Dr. Moreau was a trained scientist, and at one time, part of the greater scientific community of Britain with a laboratory. But he broke the rules, his purpose in pursuing the science he did was not for the greater good and the scientific community rejected his work. What ensues in the story is a result of being excluded from the greater scientific community. Moreau represents the needs for science to be held within a set of standards.

Experimentation could not just occur without guidelines to follow that helped to ensure (to an extent possible) that the science would be for the greater good of society. The members of the X Club worked hard to present science as a clear and disciplined study that was deserving of authority. The expectations they worked hard to create are the same expectations that Moreau broke. The fear of science and the question of progress were not unique to the writers or artists of the nineteenth century, such depictions were representative of the greater cultural perceptions of science. And these culturally embodied characters are incredibly important to the way that science worked within culture. And professionals of science and popularizers of science had a job to do to show that science was more than Frankenstein. Science was more than pomp, pride, and personal gain. The fictional depictions of the scientist presented as the final collective provide a distinct perspective on science and the scientist in the nineteenth century, and a study of nineteenth century science would not be complete without understanding how the science and scientist found its way into the greater cultural web.

This project is part of a larger trend to reconnect the science network because when approached together, better things can result. The social nature of science aided in some of the greatest innovations in the history of science. Using the imagination to fill gaps where there just was not enough knowledge allowed for progress and continued innovation in scientific theory rather than halting the work when one reached a road block. Arizona State University, among others, recognizes this need to reunite the science network. Reconnecting scientific theory and thought with the creative nature of the mind is part of goal of the Center for Science and the Imagination because there is a value in connecting multiple ways of thinking when the aim is innovation. That is science in the real world. The writers, popularizers, club members, and professionals all are part of and add to how we understand the scientist. This is true today and it was true for the nineteenth century science, too.

Much of the work done throughout this project has emphasized the social nature of science. The necessity of community and extensive nature of that community including writers, practitioners, and the public, help to create an understanding of the scientist. Latour in *Reassembling the Social* attempts to redefine the way that we consider the term "social". For Latour, the social signifies a phenomenon, it "designate[s] a stabilized state of affairs, a bundle of ties that, later, may be mobilized to account for some other phenomena" (1). He continues his explanation of the term social by dictating "I am going to define the social not as a special domain, a specific realm, or a particular sort of thing. But only as a very peculiar movement of re-association and reassembling" (7). The scientist in the nineteenth century is, by Latour's definition, social. A scientist is not one specific thing that exists only at one specific time, it is a hybrid that is constantly re-associating and reassembling as the science network changes and grows. Foucault aids in taking the idea of the social scientist even further through his discussion of genealogy. Foucault writes "I would call a genealogy, that is, a form of history which can account for the constitution of knowledges, discourses, domains of objects, etc., without having to make reference to a subject which is transcendental in relation to the field of events or runs in its empty sameness throughout the course of history" (59). I would argue that this project, in a way, is a form of genealogy: a history of nineteenth-century scientist that necessitates an accounting for the influential collectives part of the science network that ultimately created the scientist. Yet, like Foucault's genealogy requires, this scientist does not transcend “in its empty sameness throughout the course of history” as the the definition or idea of a scientist is constantly transforming due to the influence of the network (Foucault 59). This project has not arrived at a set and conclusive definition for the scientist in the nineteenth century. Rather, in a sense, it has shown the opposite. In a search for what defined the emerging scientist, the result is a far more complex understanding of the constantly changing influences that marked science throughout the nineteenth century. Therefore, there is no concrete definition of what constitutes the emerging scientist. But we have not failed in this endeavor because what is clear and has come to be clear through this investigation is the nuanced nature of science and the vibrant diversity of actors in the sub-networks, or collectives, present during the nineteenth century.

There is inherent value in connecting modes of thinking and thinkers rather than separating and isolating them. The nineteenth century was home to the second scientific revolution and created innovations in science and technology that are unmatchable, and the scientists did not achieve these things like Frankenstein or Moreau holed up in laboratory or on an island in the middle of nowhere. The steam engine, laws of thermodynamics, and evolutionary theory came to be through the multitude of influences in the science network. The scientist, like these innovations, is too a product of a network of influence and as a result, one cannot understand the emerging scientist of nineteenth-century Britain without understanding the science network that helped create it.

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