A HISTORY OF THE CONCEPT OF SCIENTIFIC LITERACY

BASED IN THE INTELLECTUAL DISCOURSE OF THE GILDED AGE

by

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(Under the Direction of J. Steve Oliver)

ABSTRACT

Understanding and embracing scientific literacy is one of the grand challenges science educators face today, particularly as influential and guiding documents from the American Association for the Advancement of Science and the National Research Council advocate for scientific literacy as a goal of science education. This research contemplates scientific literacy through the lens of Gilded Age intellectuals. The foundation of the research is on Edward Livingston Youmans' book from 1873, *The Culture Demanded by Modern Life* (*CDML*), which is a compendium of addresses and arguments on the claims of science education. The book includes the essays of Gilded Age scientists such as Michael Faraday, Thomas Henry Huxley, Herbert Spencer, John Tyndall, William Whewell, and others. An understanding of the discourse of *CDML* is augmented by examination of diverse primary sources of intellectual discourse from the Gilded Age as well as many secondary sources from both the twentieth and twenty-first centuries. By looking at why our forebears thought that scientific literacy should be a goal of science education, we have a great opportunity in the present to think about our own goals for science education. Understanding the past, particularly the ideas of the past, may help us to think about our own underlying assumptions today. While there is certainly an abundance of current literature on the topic of scientific literacy, this historical approach to scientific literacy can breathe fresh air into the ongoing discussion of scientific literacy in science education.

INDEX WORDS: Scientific Literacy; Gilded Age; history of science education; Edward Livingston Youmans

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TABLE OF CONTENTS

It was the best of times, it was the worst of times; it was the age of wisdom, it was the age of foolishness; it was the epoch of belief, it was the epoch of incredulity; it was the season of Light, it was the season of Darkness; it was the spring of hope, it was the winter of despair; we had everything before us, we had nothing before us; we were all going directly to Heaven, we were all going the other way.

Charles Dickens, *A Tale of Two Cities*

CHAPTER 1

INTRODUCTION

The Gilded Age

While Charles Dickens wrote these words to portray Paris and London during the last decade of the eighteenth century, they could just as easily be used to represent America during the last three to four decades of the nineteenth century. The Gilded Age, the label used to represent U.S. society in the time period covering the last third of the nineteenth century, was a conspicuous time. According to the writings of the time, it was a "transitional, critical and formative" time for those living though it.[1] Caroline Winterer, a late-twentieth century historian, described the four decades after the Civil War as being marked by "cataclysmic intellectual and social changes."[2] The people of the nation were split along various physical, ideological, and social lines: north versus south, east versus west, labor versus capital, agriculture versus industry, borrower versus lender, and native versus immigrant; furthermore, the population of the nation

[1] Thwing, *History of Education*, v.
[2] *Culture of Classicism*, 99.

doubled in the last third of the century.[3] The term *Gilded Age* was coined by Samuel Clemens (a.k.a., Mark Twain) with his book of the same name. For many readers, the term was largely pejorative with Twain's book making a "seething commentary on society" during the time period.[4] Henry Adams, having himself lived through the latter six decades of the nineteenth century, wrote that "between 1850 and 1900 nearly every one's existence was exceptional."[5] It is interesting to note how people of almost all times periods believe that they are living through exceptional times – this research looks at some of the ways of thinking and aspects of life that made the Gilded Age an exceptional time, particularly in the context of science education.

It was an age of excess, where a dazzling façade of elegance covered up terrible economic inequities, with the rich living in high style while the majority faced social ills such as urban slums, crime, poor sanitation, bloody rioting, and disorderly strikes. Jacob August Riis, a Gilded Age social reformer and journalist, wrote a book in 1890 entitled *How the Other Half Lives* that documented the squalid living conditions in New York City slums in the 1880s. He began his book with the following:

> Long ago it was said that "one half of the world does not know how the other half lives." That was true then. It did not know because it did not care. The half that was on top cared little for the struggles, and less for the fate of those who were underneath, so long as it was able to hold them there and keep it own seat.[6]

There is little evidence that a man like Cornelius Vanderbilt II, building his $150 million mansion "The Breakers," cared for the distressing living conditions of the poor. The disparity between the living conditions of the rich and the poor was drastic and yet seen within only a few

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[3] Menand, *Metaphysical Club*; and Winterer, *Culture of Classicism*.
[4] St. Louis University, "Investigating the Gilded Age," 1. Harris, "Gilded Age Reconsidered," indicates that the term *Gilded Age* was not really used by historians until closer to the 1920s.
[5] Adams, *Education,* 38.
[6] Riis, *How the Other Half Lives*, 1.

city blocks. Places like the Fifth Avenue Hotel were equipped with private baths, a fireplace in every room, a service staff of 500, a steam powered elevator, running hot water, and gas lighting; at the Astor's Fifth Avenue mansion they had plates of silver and gold on which they served such food as terrapin, beef, duck, partridge, truffles, quail, and fresh fruit.[7] Wealthy characters in Twain's *The Gilded Age*, "Filled the place with a suffocating sweetness procured at the perfumer's. Their costumes, as to architecture, were the latest fashion intensified; they were rainbow-hued; they were hung with jewels – chiefly diamonds."[8] Juxtaposed with these examples of "shameful opulence" were apartment buildings where people lived in a largely unrecognizable extreme from the other examples. The squalor was exemplified by the use of the airshaft as a receptacle for garbage that remained rotting at the bottom.[9] The difference in living conditions between the rich and everybody else exemplify what is meant by the term *Gilded Age*, where a gilded superfluity exhibited by a few covered society's problems that were experienced by the many.

In addition to the prevalent economic plutocracy**,** the Gilded Age was also a time for the emergence of big business, the centralization of U.S. government and industry, and the commonplace occurrence of scandal and political corruption. ("To be sure you can buy now and then a senator…we would have to go without the services of some of our ablest men, sir, if the country were opposed to bribery."[10]) Increases in the wealth of individuals and business combined with the centralization of government strained the chief domestic and social institutions. As for the employment of the lower classes, it seems that unemployment was

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[7] Kaplan, *Astors Owned New York.*
[8] Twain, *Gilded Age,* 21.
[9] Winterer, *Culture of Classicism,* 99; and Center for the History and Ethics of Public Health, *"1870s."*
[10] Twain, *Gilded Age*, 54, 55; Harris, "Gilded Age Reconsidered." See Appendix C for a more detailed look at how historians throughout the twentieth century have interpreted the Gilded Age.

"ubiquitous among the working class."[11] On top of that, common people were increasingly faced with violence and threats of violence and breakdowns of civil order. Apparently, however, the vast majority who were faced with these social ills found some diversion from their own troubles, as newspapers in the late 1870s ran a "usual parade of murders, scandals, calamities, sensations, and political rants."[12] Although things were bad, the public seem to have distracted themselves by reading about the misfortunes of those worse off.

Scholars of the period report that the actions of many people during this time can be viewed as reaction to the bloody and devastating Civil War. Ideologies like individualism, localism, minimal taxation, laissez-faire economics, and hostility to government were perhaps natural repercussions of Civil War political and military actions and decisions. Other prevalent beliefs of the time included concepts like natural law doctrine, which presumed that law is set by nature, not politics; scientific determinism, which presumed that there is no free will because everything proceeds as the inevitable consequence of antecedents; and social Darwinism, which presumed that poverty and destitution were nature's way of weeding out the weak in society, allowing the fittest to survive.[13] These ideas, that the poor and weak do not need to be helped because it is nature taking its course, or that there is no free will because our actions are governed by statistical laws of error, where "People who murder – like people who marry and people who commit suicide – are only filling a quota that has been preset by social conditions," point to a society where excess, self-indulgence, and self-serving ideas were prominent.[14]

The philosophy of pragmatism was conceived during the Gilded Age, partly as a consequence of the above ways of thinking. William James, one of the founders of pragmatism,

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[11] Moen, "Gainful Employment;" and Margo, "Labor Force," as cited in James and Thomas, "Golden Age," 980.
[12] Thwing, *History of Education*; Sproat, *Best Men*; Harris, "Gilded Age Reconsidered;" and Klein, *Power Makers,* 150.
[13] DeBoer, *History of Ideas*; and Menand, *Metaphysical Club*.
[14] Menand, *Metaphysical Club*, 188.

"elevated reason and free will. He helped rescue his and future generations from the intellectual restrictions imposed by absolute laws and closed systems."[15] In other words, pragmatists disagreed with determinist mindsets. Henry Adams wrote that Americans living after the Civil War "disliked being told what to do, and how to do it."[16] Individualism and self-determination were prominent ideologies of the time period.

Despite the negative connotation put on the Gilded Age by Twain and others, positive (and even great) things did happen. John Sproat, a mid-twentieth century historian, wrote, "Scholarship of more recent vintage has by now persuaded us that the Gilded Age, with all its glaring faults, was not simply an orgy of self-indulgence, that it was also an era of profound and fascinating change in every area of American life."[17] Some of the more constructive things that are the legacy of the times include the streetcar, typewriter, alarm clock, vaccinations, brand names, the lunch hour, paid vacations, apartment houses, spectator sports, and professionalized hospitals.[18] The Gilded Age was also an innovative time for science and technology. During the last third of the nineteenth century the first transatlantic telegraph cable was laid (1866), Bell developed his telephone (1876), Edison invented the phonograph (1877) and the incandescent light bulb (1879), and he illuminated the New York Times building (1881), Tesla and Westinghouse developed electric motors (1888), and the x-ray was developed (1895).[19] Furthermore, the steel and oil industries boomed. Improved steel was responsible for the improvement and development of locomotives, railroad tracks, skyscrapers, and bridges.[20]

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[15] Buenker and Buenker, *Encyclopedia of the Gilded Age*, 572.
[16] *Education*, 239.
[17] *Best Men*, vii.
[18] Harris, "Gilded Age Reconsidered."
[19] Amsler, "New Frontiers;" Buenker and Buenker, *Encyclopedia of the Gilded Age*; Klein, *Power Makers*; and St. Louis University, "Investigating the Gilded Age."
[20] St. Louis University, "Investigating the Gilded Age."

The increasingly scientific and technological aspects of life were accompanied by the growing prestige of science. In fact, Gilded Age society became somewhat infatuated with science. John Sproat called this a "national infatuation with progress;" Maury Klein, a twenty-first century historian, called it an "American love affair with technology;" and Craig Hazen, another twenty-first century historian, called it "the common American's infatuation with things scientific," writing that there was "a vigorous and sustained interest in science among the common people."[21] Scientific knowledge was spreading to the public via the lyceum movement (i.e., public lecture series) and newspaper stories. Importantly, scientific knowledge was making it s way into the school system.

The Gilded Age and Science Education

Whether or not the Gilded Age is seen as a time of inequality and social disorder or as a time of great scientific advancement, it is broadly viewed as a time of rapid and immense change. The scientific and societal changes of the Gilded Age make it an interesting time period to investigate. More significant than this though, the Gilded Age was a formative time for discourse on science education.

During the last third of the nineteenth century there was a drive by prominent scientists to have science taught in the secondary schools, and an important part of this campaign was intellectual discourse, shared both among the scientists and with the public, devoted to the matter. It is surprising that science, while today a seemingly indispensible part of the school curriculum, was not always included in the subjects of the school day. With the end of the Civil War and the onset of industrialization and scientific progress, people began to question the value of the traditional school curriculum of Latin, Greek, and arithmetic. Intellectual discourse on teaching science, which accelerated in this period, was responsible for developing ideas relative

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[21] Sproat, *Best Men*, 5; Klein, *Power Makers*, 177; and Hazen, *Village Enlightenment*, 8, 11.

to how education could better prepare students to live in a modernizing world while still achieving the educational goal of teaching students how to think.

In terms of science education and the Gilded Age, George DeBoer, a late twentieth century historian of science education, wrote, "many of our modern ideas in science education were very well elaborated in the nineteenth century."[22] In particular, it was in the last third of the nineteenth century that there was a profound elaboration of the purpose of teaching science. For example, science was coming to be seen as a subject that could promote mental discipline (i.e., the prevailing purpose of education at the time) and impart useful knowledge at the same time. This was unlike the traditional and deeply entrenched Latin and Greek curricula, which promoted mental development at the expense of useful knowledge. In another example, teaching science was seen as a way to prepare students for dealing with socially relevant questions that were scientific in nature (e.g., sanitation, health, scientific hoaxery), and also to prepare students for life in a world that was increasingly dominated by science and industry.

The above examples are merely a few of those elaborated during the Gilded Age about the purpose of teaching science. The intellectual discourse of the Gilded Age was influenced by society, culture, politics, war, and economic conditions. This research probes deeper into the discourse on the inclusion of science in the schools, placing it within the context of the Gilded Age in order to better understand their beliefs, their dialogue, and their arguments.

The Culture Demanded by Modern Life

The research being reported here is anchored on Edward Livingston Youmans' book, *The Culture Demanded by Modern Life* (*CDML*). This collection of essays was a mid-nineteenth century contribution to the discourse on the purpose of teaching science.[23] As such, given its

[22] DeBoer, *History of Ideas*, xii.
[23] Youmans, *Culture Demanded by Modern Life*, 1873; reprint, 2006.

original publication date of 1867 it was an early contribution to that body of work. In America during the Gilded Age, according to Youmans' biographer, John Fiske, "there was much intellectual eagerness, along with very meager knowledge, and few persons had access to authoritative sources of information." Youmans' life-long purpose was to diffuse knowledge and appreciation of science among the American people.[24]

Edward LivingstonYomans' purpose for the book was "the compilation of a volume designed to present the increasing claims of science upon teachers and the directors of education."[25] According to John Fiske, Youmans had often read insightful essays and addresses on the topic of science education, but "they had been published in ephemeral journals or shelved in volumes of *Transactions*. He now proceeded to carry out his plan of publishing a selection of such essays by the most eminent writers of the day, with an introduction by himself, setting forth the subject in its widest relations."[26] When the book was published in 1867 it was favorably received, "and there can be no doubt that its contents, in their connected form, were vastly more influential for good than in the separate and narrow fields of their original issue."[27]

CDML is a collection of Edward Livingston Youmans' lectures and those of over twenty other highly influential Gilded Age scientists and scholars (e.g., Michael Faraday, Thomas Henry Huxley, Herbert Spencer, John Tyndall, and William Whewell). Each of the authors addressed the issue of teaching science in the schools. Youmans was ideally suited to serve as the volume's editor given his keen involvement in the intellectual discourse of the Gilded Age on science education. By pulling together the ideas of a variety of scholars he was able to frame a comprehensive view of science education for the first time in the history of education in the

[24] Fiske, *Edward Livingston Youmans*, 111.
[25] Youmans, as cited in Fiske, *Edward Livingston Youmans*, 106.
[26] Fiske, *Edward Livingston Youmans*, 221.
[27] Ibid., 227.

United States. Youmans' accomplishment of compiling various but related discussions that in combination convey a complete argument for teaching science has been noted by several scholars across the years since its publication. John Fiske, Youmans' friend and biographer, wrote that *CDML* was an "excellent original discussion, showing the need for wider and later training in science."[28] A century later, Caroline Winterer called Youmans a "scientific popularizer" whose book was instrumental in the decisions that led up to the inclusion of science in the schools.[29] Recently George DeBoer wrote that Youmans was among the first to advocate for science in the schools, and that he was an instrumental player in the discourse.[30]

Scientific Literacy

While the scholars in *CDML* put forth a multitude of arguments for teaching science, I have pulled from their various essays those ideas that relate to our modern day concept of scientific literacy. Among the themes presented in the combined arguments in *CDML*, the theme of scientific literacy (although the term is not used as such in the document) is surely the most prevalent line of argument used. While I used the discourse of *CDML* as the foundation of the research, I also investigated other Gilded Age literature that discusses teaching science in the schools in order to gain a more thorough understanding of what scholars from the Gilded Age thought about scientific literacy and how it fit in with or met the purposes of general education.

The research explores a variety issues noted by Gilded Age scholars about the inclusion (or not) of science in the schools. But foremost, the research examines how these Gilded Age scholars identified and proposed reform relative to the idea that is now called scientific literacy. Scientific literacy is emphasized because understanding and embracing scientific literacy is one

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[28] Fiske, *Century of Science*, 98.
[29] Winterer, *Culture of Classicism*, 105. It is worth noting that Winterer's historical perspective is that of a classics scholar, so her interpretation of science education (which she interprets as usurping classical education) is not seen in a positive light.
[30] DeBoer, *History of Ideas.*

of the grand challenges science educators face today. An underlying tenet of both *Science for All Americans* [*SFAA*] and the *Benchmarks for Scientific Literacy* [*Benchmarks*] is that modern day science education in America can and should educate students to be scientifically literate citizens. Furthermore, the *National Science Education Standards* [*Standards*] state, "This nation has established as a goal that all students should achieve scientific literacy".[31] With these influential and guiding documents advocating for scientific literacy as a goal of science education, it is clear that scientific literacy is a modern challenge associated with science education that impacts our society. In addition to these books, a simple Internet search with the term "scientific literacy" brings up more than 14,000 scholarly articles, indicating that it is a dynamic force in science education today. Furthermore, understanding and implementing scientific literacy has been presented as a challenge throughout much of the history of science education.[32]

I have identified five distinct nuances or emphases in the modern day literature (i.e., spanning approximately the last four decades of the twentieth century) on scientific literacy, each of which has multiple subsets. These nuances serve to ground the rationale for the inclusion of science in the curriculum as described by these 19th century authors. They are:

- Social responsibility – Includes science in a democracy; science for decision-making, particularly on controversial socio-scientific issues; science to promote social responsibility; science to stimulate citizenship; the ability to understand scientists and what one reads or hears in the news; the ability to choose one's experts; and the ability to communicate in science

[31] National Research Council [NRC], *Standards*, ix.
[32] Oliver, Jackson, Chun, et al., "Concept of Scientific Literacy."

- Interaction of science and society – Includes STS; the use of science in our everyday lives; science as a social activity; and science as a collaborative human endeavor
- Organization of knowledge – Includes understanding the major concepts of science; understanding the processes of science; and learning to use the skills of science
- Progress of science – Includes the promotion of science itself; and the promotion or aid to industry, business, and economics as relates to science
- Social justice – Includes SES, gender, and ethnicity in science

The following is an abbreviated overview of each nuance, but an in-depth look at each nuance can be found in Appendix A.

Writings that developed the social responsibility category, while broad, contain by far the most frequent reasons given for promoting scientific literacy. This category covers those ideas that relate to responsible and active citizenship such as being able to understand scientific issues one reads in the media, being able to discuss these issues knowledgeably, and, moreover, being able to make informed democratic decisions about scientific issues. Here, an understanding of the concepts and principles of science is less important than decision-making skills and the ability to participate in a democracy where scientific issues arise. As Michelle McGinn and Wolff-Michael Roth view it, "scientific knowledge as competence in scientific discourses rather than as bodies of facts and theories."[33]

[33] McGinn and Roth, "Preparing Students," 19.

The interaction of science and society is another common nuance of modern day discourse on scientific literacy. Morris Shamos calls this "science-based societal issues."[34] The standard argument given for promoting scientific literacy here is for students (and thus the participating citizens they will become) to be aware of, and be able to respond to, societal impacts of science.[35] Henry Bauer, a late twentieth century critic of the discourse on scientific literacy, declares that rather than making an issue of creating scientifically literate students, we should focus our efforts on helping students to see that science is a human activity.[36] To Bauer, it is better for the student to try to understand science's relationship to society rather than strive for the nebulous concept of scientific literacy.

The third theme in the modern day literature on scientific literacy, the organization of scientific knowledge, emerged from writings that focused on the importance of understanding the process of science, knowledge of the facts and principles of science, and acquiring the skills of scientists. The organization of scientific knowledge is not seen as the sole purpose or criterion of scientific literacy; rather, the organization of scientific knowledge is merely a necessary component of the scientifically literate person. For instance, knowledge and understanding of a concept like the phases of matter is an integral component of comprehensive scientific literacy.

The progress of science nuance, the fourth that is elaborated on in Appendix A, within the discourse on scientific literacy is somewhat like that of the organization of knowledge described above. As in the writings that created the organization of scientific knowledge theme, the progress of science itself is never seen as the sole purpose or criterion of scientific literacy; rather, the progress of science is a minor aspect of a science education that advances scientific

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[34] Shamos, *Myth of Scientific Literacy*, 77.
[35] Bybee, "Achieving Scientific Literacy;" Culliton, "Dismal State;" Evans, "Scientific Literacy;" Ewing et al., "Improving Student Attitudes;" Hofstein and Yager, "Societal Issues;" Miller, "Scientific Literacy;" and Mitman, Mergendoller, Marchman, and Packer, "Components of Scientific Literacy."
[36] Bauer, *Scientific Literacy*.

literacy. More importantly in this nuance, a scientifically literate student body (or general public) is a necessity for the progress of science.

Finally, the fifth nuance is given the label of scientific literacy for social justice. As such, scientific literacy for social justice sounds similar to the nuance labeled scientific literacy for social responsibility. The analysis of the Gilded Age writings did not distinguish this final nuance, but rather it has emerged as a characteristic of writings on scientific literacy at the end of the twentieth century. Whereas scientific literacy for social responsibility emphasizes using one's scientific literacy for democratic purposes, to be an effective citizen, to understand and engage in discourse on scientific issues in the public agenda, and make informed decisions on these issues, scientific literacy for social justice is something quite different. Those who see scientific literacy as a means towards social justice see science teaching as a political act.

These five nuances have been pulled out of the modern day (i.e., 1958-2007) literature on scientific literacy, the purpose of which was to better understand the Gilded Age discourse since the term scientific literacy was not used then. As will be elaborated later, social justice issues are not seen in the Gilded Age literature, but it has been included as a modern day nuance because of the important role it plays today and also to use as a contrast with the Gilded Age literature.

In addition to the importance scientific literacy plays in science education today, scientific literacy issues were also a concern in the Gilded Age. Amongst the numerous arguments put forth by the scholars in *CDML*, one finds that much of the Gilded Age reasoning for teaching science is distinctly comparable to our modern day notion of scientific literacy. The current, generally accepted, definition of scientific literacy comes from the American Association for the Advancement of Science [AAAS] and the National Research Council [NRC]. While there is not necessarily consensus amongst science education scholars on the interpretation of what it means to be scientifically literate, the definitions put forth in *SFAA*, the *Benchmarks*, and the *Standards* are often the point of reference for the debate. *SFAA* defines a scientifically literate person as someone who is “aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individuals and social purposes.”[37] The *Benchmarks*, a companion to *SFAA* that raises scientific literacy issues closer to the curriculum and instruction, define a scientifically literate person in much the same way as *SFAA*. With these two publications, the AAAS “promotes literacy in science, mathematics, and technology in order to help people live interesting, responsible, and productive lives.”[38] The *Standards* give an indication of why scientific literacy should be a goal of science education: “Scientific literacy enables people to use scientific principles and processes in making personal decisions and to participate in discussions of scientific issues that affect society. A sound grounding in science strengthens many of the skills that people use every day, like solving problems creatively, thinking critically, working cooperatively in teams, using technology effectively, and valuing life-long learning.”[39] (A more comprehensive look at the modern day literature on scientific literacy can be found in Appendix A.)

The following are some examples of scientific literacy issues raised in the discourse of *CDML*: acquiring the ability to think like a scientist; using the knowledge and principles of science in everyday life; and understanding aspects of the nature of science such as the limits of scientific conclusions, what things can and cannot be answered by scientific investigation, and the weighing of probable evidence. These examples are certainly not exhaustive; rather, they are

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[37] AAAS, *SFAA*, xvii.
[38] AAAS, *Benchmarks*, xi.
[39] NRC, *Standards*, ix.

merely representative of scientific literacy concerns brought up in *CDML.* After a thorough exploration of the themes in *CDML*, it became clear that the large majority of arguments come back to some aspect of scientific literacy as that concept is described in the current time. Thus scientific literacy became the unifying theme of the discourse.

By looking at a modern day issue in science education through an historical lens, I plan to accomplish a number of things. Firstly, I aim to show that *CDML* was something of an intellectual revolution that generated a dramatic shift in thinking about education; Edward Livingston Youmans, by pulling together the ideas of a variety of scholars, was able to frame a comprehensive view of science education for the first time in the history of education in America. I aim to show that *CDML* was a seminal work that enshrined a powerful notion of scientific literacy as a way of achieving the goals of education. Moreover, I will establish that the formation of the notion of scientific literacy, as seen in *CDML*, was shaped by a variety of conditions (placing the discourse within the cultural, political, and philosophical contexts of the Gilded Age) and factors (e.g., schooling, public health, scientific fraud, and the increasingly scientific nature of life).

Historiography

Historians have not addressed the historical issue of scientific literacy as seen through the lens of Gilded Age intellectuals. They have, however, dealt with the intersection of science and education.

Historians throughout the twentieth century basically held one of two beliefs about Gilded Age science and industrialization and their effects on society and education. For the first part of the twentieth century the general opinion was that science and industrialization were harmful and unfavorable. Progressive historians such as Ellwood Cubberley and Merle Curti maintained that modernization created burdens on society and social institutions, including schools, and that any progress that was made during the Gilded Age was made in spite of science and industry.[40] To Progressive historians, the interests of big business epitomized the depravity of the Gilded Age. .

Neo-Progressive historians, writing in the 1960s for the most part, were similar in spirit to their Progressive predecessors, although they tended to take their interpretation a step farther, portraying even more conflict and repression. Historians such as Joel Spring wrote at a time when America's society was changing, as reflected in the Civil Rights Movement. Neo-Progressive historians were also influenced by American's changing position in the world, as reflected in the easing of the Cold War, Europe's declining dependence on America, and the Vietnam War.[41] To Neo-Progressive historians, the Gilded Age was a time of intense conflict and violence. For Spring, the entire history of American education, from colonial to modern times, is a series of conflicts and violence.[42] For Richard Hofstadter, science did more than place burdens on the schools, it effectually destroyed American education by turning it into the merely practical, ruining the intellectual aim of education.[43]

What Progressive historians failed to consider were the greater complexities of the Gilded Age and the effects on education; their focus on business and politics as the enemy was too narrow. The Neo-Progressive focus on conflict and repression, while certainly a valid representation of the time, is almost too simplistic. Research on the intellectual discourse of science and education during the last third of the nineteenth century that incorporates scientists, educational reformers, university presidents, university professors, school administrators,

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40 Cubberley, *Public Education*; and Curti, *Social Ideas*.
41 Breisach, *Historiography*.
42 Spring, *American School*.
43 Hofstadter, *Anti-Intellectualism*.

doctors, and other intellectuals, plus research that situates the discourse within contextual elements, allows for a more complex interpretation of the intricacies of the age.

The second general belief held by historians in the twentieth century was virtually the mirror opposite of that described above. In the latter part of the nineteenth century Conservative historians saw science and industrialization as beneficial and favorable. George DeBoer portrayed science and industrialization as spurring on positive educational reform. Unlike the Progressive and Neo-Progressive points of view, Conservative historians like DeBoer and Carl Kaestle maintained that progress made during the Gilded Age was made *because* of science and industry.[44] Conservative historians such as Louis Menand downplayed conflict, repression, and cynicism, instead emphasizing transition and laissez-faire economic policies.[45]

Conservative historians tended to mute conflict and underplay social justice issues.[46] While their celebration of achievements and accomplishments is commendable, they generally failed to uncover important tensions between science and education during the Gilded Age. Science and industrialism *did* create tensions in post-Civil War America, and these tensions should not be overlooked or diminished. An intellectual history of scientists and educational reformers of the time, especially one that includes counterpoints to their pro-science arguments, reveals some of the important friction of the time period that was instrumental in creating the educational reform of adding science to the curriculum. (For a more detailed historiography on historical interpretations of Gilded Age science and education please see Appendix C.)

[44] DeBoer, *History of Ideas*; and Kaestle, *Pillars of the Republic.*
[45] Menand, *Metaphysical Club*. The historians that I have used as examples in this discussion (i.e., Cubberley, Curti, Spring, Hofstadter, DeBoer, Kaestle, and Menand) can arguably be classified in a number of ways. For the purposes of this particular vein of their research (i.e., their treatment of Gilded Age science and education), I stand by my categorizations of these historians.
[46] Foner and Mahoney's book, *America's Reconstruction,* on the Reconstruction is an obvious exception to this. Their focus on African Americans and Reconstruction is a commendable work on social justice.

Part of the importance of this research lies in the paucity of historical research on *CDML* and its intellectual discourse. It is important to note that this research is not a literary analysis of *CDML*; rather, the research will use *CDML* as an anchor to study Gilded Age intellectual discourse on incorporating science into the schools, particularly that discourse associated with scientific literacy. With that said, there is certainly a lack of awareness of (or study of) the discourse in *CDML*, and a few examples will suffice to prove this point. Two current histories of American education do not so much as even mention Edward Livingston Youmans or *CDML*.[47] Two older histories of education (published in 1919 and 1936) also make no mention of Youmans or his book.[48] In fact, none of these histories make mention of the origins of science education at all; any reference to science education is in the form of science *of* education and the move to study education and teaching scientifically.

Herbert Spencer and Thomas Henry Huxley, more so than Youmans, are more often credited as educational reformers. For example, Rodger Bybee and George DeBoer cite both men as European influences in the science curriculum; Joy Palmer cites both men as major thinkers on education; and Robert Quick devotes an entire chapter to Spencer in his book on education reformers.[49] For his part, Lawrence Cremin does make passing mention of Youmans and *CDML*, but both are written about (very perfunctorily) only in relation to Youmans' relationship with Charles Eliot.[50] John Fiske does much more justice to the importance of Youmans, devoting an entire chapter to him in his book, *A Century of Science*, and writing a bibliography of Youmans, his personal friend.[51]

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[47] Spring, *American School*; and Watras, *History of American Education*.
[48] Cubberley, *Public Education*; and Wilds, *Foundations of Modern Education*.
[49] Bybee and DeBoer, "Goals for the Science Curriculum;" Palmer, *Fifty Major Thinkers*; and Quick, *Educational Reformers*.
[50] Cremin, *Metropolitan Experience*.
[51] Fiske, *Century of Science*; *Edward Livingston Youmans*.

As for histories of science education (as opposed to the histories of general education cited above), the prospects are almost as bleak. Rodger Bybee and George DeBoer make passing mention of the intellectual discourse found in *CDML* (without explicitly referencing the book), writing that the educational goals of personal intellectual development tended to compete with the educational goals of learning science facts and information, and that the methods of science were also regarded as important.[52] This cursory treatment of science education in the latter third of the nineteenth century seems to be common in the science education literature. DeBoer devotes one single paragraph to the time before 1893 (i.e., the report of the Committee of Ten) in his article on scientific literacy, writing that men like Thomas Henry Huxley, Herbert Spencer, Charles Lyell, Michael Faraday, John Tyndall, and Charles Eliot were instrumental in publicly advocating for the inclusion of science in the school curriculum.[53]

While George DeBoer's article cited above does not do justice to *CDML*, DeBoer's book, *A History of Ideas in Science Education*, seems to be the most detailed and insightful current study of Edward Livingston Youmans and *CDML* in both science education literature and general education literature. While DeBoer also cites Thomas Henry Huxley and Herbert Spencer (as is common) for their influential discourse on science in the schools, he credits Youmans, with *CDML*, for waging "a lively assault on the existing classical curriculum."[54]

As can been readily seen from the discussion above, much more can still be learned about the intellectual discourse in *CDML*. By anchoring this research on the discourse in *CDML*, not only will new life be breathed into this document, but we can begin to put together a comprehensive understanding of Gilded Age discourse on teaching science, especially as relates to scientific literacy. By using the methodology of historical research and by studying other

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[52] Bybee and DeBoer, "Goals for the Science Curriculum."
[53] DeBoer, "Scientific Literacy."
[54] DeBoer, *History of Ideas,* 17.

intellectual discourse from the time period that addresses science education, I have augmented my understanding and interpretation of the topic.

Organization of the Dissertation

The arguments as laid out by the various scholars in *CDML* shape the foundation of the research, while other literature from the time period is used to expand these arguments, placing them within the context of other Gilded Age opinions, exploring both corroborating and conflicting arguments and considering further conditions and ideas of the time period. Secondary sources spanning both the twentieth and twenty-first centuries are also examined to further illuminate the research.

In my third reading of *CDML*, I created histograms to establishing the frequency of occurrence of different threads of argument. In doing so, five different arguments for teaching science were found to run through the literature. The research is therefore organized along these five arguments, with a chapter devoted to the thorough exploration of each argument. Although all of the arguments are treated as discrete threads in the research, it will become apparent to the reader that aspects of the various arguments are interconnected, and that they form a comprehensive and multifaceted argument for including science in the school curriculum. Briefly, the five arguments are as follows:

Modern Knowledge represents the desire to update the curriculum. The idea here was that current education was somewhat obsolete, that it was based on a system of education laid down centuries ago, and that the content (i.e., Latin, Greek) was also outdated. An education that was more modern in spirit would include knowledge that has been gained since the time of the ancients, and this would, naturally, include science.

Functional Education represents the idea that science should be taught in the schools to give students a utilitarian education that will help them to cope in a scientific and technological world, giving them the ability to think like scientists in their everyday lives, prepare them for some of their citizenship duties, prepare them for life in a scientific world, and give them some skills they can put to use in their everyday lives.

Scientific Fraud was apparently somewhat of a problem during the nineteenth century, and the intellectual discourse is rife with examples of intellectuals who felt the need to combat the scientific hoaxery and quackery that was prevalent in society. An education in science, particularly the skills related to scientific literacy, would presumably help this situation.

Public Health was another consequential issue during the study period. Personal health issues, personal and public hygiene issues, and medical issues such as knowing when and when not to see a doctor, improving the medical field by giving pre-med students a leg up on science knowledge, and giving doctors more authority, were important things that needed to be addressed and rectified. A scientific education in the secondary schools was the Gilded Age answer to solving some of these problems.

Scientific Progress was an important, if minor, aspect of the intellectual discourse during the study period. In effect, the argument was that science ought to be taught in the schools in order to create future scientists so that science itself could progress.

Each argument will comprise a discrete chapter, with the theme of scientific literacy running through all chapters. Each argument will be introduced via discourse from *CDML* and then further explored and expanded on with other literature from the time period and insights from secondary sources from the twentieth and twenty-first centuries.

The whole of modern thought is steeped in science … Modern civilization rests upon physical science; take away her gifts to our country, and our position among the leading nations of the world is gone tomorrow.

Thomas Henry Huxley, "On the Study of Zoology."

CHAPTER 2

MODERN KNOWLEDGE

Introduction

This chapter, as with the subsequent four chapters, will be presented in a manner that uses the discourse in *CDML* as a foundation. This discourse will then be examined and analyzed utilizing other Gilded Age literature and various secondary sources from both the twentieth and twenty-first centuries. As such, in the first section of the chapter the arguments found in *CDML* will be laid out as they appear in that book, with discussion and elaboration being saved for the second section of the chapter. Finally, in the third section of the chapter the Gilded Age discourse will be examined through the lens of our modern day notions of scientific literacy.

In this chapter I will explore those arguments that related to the modernization of the curriculum. The works of scholars examined here show that they were concerned that the traditional curriculum of Latin and Greek was not appropriate for educating students to face the modern scientific world. And in their own way, each of these arguments developed in this chapter contribute to the overall argument that focused on the necessity of reforming the curriculum to include the teaching of science. Explorations into education in a democracy, where the education system in a democracy should be based on the needs of the majority, will be accompanied by explorations into the perceived educational needs of the Gilded Age. Furthermore, the discourse between Gilded Age classicists and scientists will be examined, with particular focus on liberal and conservative points of view.

Modern Knowledge as Seen in *Culture Demanded by Modern Life*

One idea scholars expressed in *CDML* was the need to teach current knowledge in schools. Most commonly, the argument made by scholars was that modern day education should teach modern day knowledge, not only the knowledge and culture of the ancient Greeks and Romans. While Edward Livingston Youmans, Thomas Henry Huxley, and Francis Wayland gave more emphasis to this argument than the other scholars found in *CDML*, men like John Tyndall and William Whewell were also concerned about this issue.

Undoubtedly there were many numbers of things, thoughts, events, innovations, or changes in life that precipitated the desire among the men in *CDML* to change what was being taught in schools. Reformers, after all, stimulate reform because they are unhappy with the current state of things, and most intellectuals involved in the discourse began with the notion that an education based on the past, particularly the ancient past, was obsolete. The point was not that classical learning (i.e., Latin and Greek languages, literature, and culture) was an inherently bad education (although there was some discussion among classicists themselves about the problems associated with the various ways it was being taught), rather it was too outdated for the modern world. Thomas Henry Huxley, in a bit of over-dramatization, claimed a boy in the year 374 A.D. would have had an identical education to boys 1500 years later; he wrote that a boy from 374 A.D. could pass through the current course of education without blinking an eye, without meeting with a single unfamiliar line of thought.[55] Although a gross oversimplification, Huxley's argument that a classical education, particularly because it omitted science, did not fit boys for modern life, was a key argument for including science in the curriculum.

One of the major arguing points here was that modern day education should not be based on the past simply because that is how things have traditionally been done. Francis Wayland, a Gilded Age educator, eloquently wrote, "God intended us for progress, and we counteract his design when we deify antiquity, and bow down and worship an opinion, not because it is either wise or true, but merely because it is ancient."[56] It is important to note that these scholars did not want educators to accept the educational plan of the past, both of the ancients themselves and of Medieval times when the classical curriculum was introduced to European society, without thinking about what they really needed from their education in their own times. John Tyndall, a prominent Gilded Age physicist, felt that "it would be treason to the trust committed to us, if we were to sacrifice the hopes and aspirations of the Present out of deference to the Past," meaning that a modern day education should take into account modern day needs.[57] This is precisely the type of thing that reformers always have to work against, the status quo of outmoded ideas, institutions, laws, and such. In the case of the intellectual discourse under investigation, those advocating for including science in the curriculum were working against a very powerfully entrenched status quo of the classical curriculum. As will be shown in each chapter however, the reformers had some pretty powerful arguments on their side that supported their cause.

That education should be decided by men of the present rather than the authority of the past was fundamental to the debate about changing the curriculum. It would be like presuming that our current day education (e.g., an educational system in the year 2000) would be

[55] "Study of Zoology."
[56] Wayland, "Modern Collegiate Studies," 438.
[57] "Study of Physics," 66.

appropriate for the year 2200 or the year 3000. Edward Livingston Youmans wrote, "Educational institutions which have been bequeathed to us by the past, and which may have been suited to their times, have fallen out of harmony with the intellectual necessities of modern life."[58] Youmans would have agreed that the educational institutions of the year 2000 would not suffice for the intellectual necessities of the year 3000, and hopefully educators in the year 3000 will also decide for themselves what educational goals meet their own needs. Rather than simply bow down and defer to antiquity (or the Middle Ages), each age should decide for themselves what defines the best education. A mindless acceptance of a classical education put all of the responsibility on the originators of that curriculum, thus relieving men of the present from the burden of decision-making. By submitting to the wisdom of the ancients and their culture or Medieval educators and their curriculum, Gilded Age educators and scholars were short changing themselves. They forgot that the men who devised the classical curriculum were also once men of the present, and that the curriculum they devised was appropriate for their own present times. Francis Wayland made an insightful observation when he wrote:

> We are just as capable of deciding it as the men who have gone before us. They were once, like ourselves, men of the present, and their wisdom has not certainly received any addition from the slumber of centuries. They may have been able to judge correctly for the time that then *was* [italics in original], but could they revisit us now, they might certainly be no better able than ourselves to judge correctly for the time that *now is* [italics in original].[59]

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[58] "Mental Discipline in Education," 1-2.
[59] Wayland, "Modern Collegiate Studies."

In other words, the knowledge of sixteenth century men about education and their plan for education was appropriate for their present time, but they had no authority in the present; men of each age should decide what best suits their present needs, not the needs of a long-ago time.

Goldwin Smith, a Gilded Age champion of educational reform, wrote that a classical education was, of course, appropriate in certain times and places. For example, during the Tudor and Stuart times in the United Kingdom the classics were the only basis for philosophy, history, poetry, and science. Latin was the language of literary, ecclesiastical, diplomatic, legal, and academic Europe.[60] He declared that each age ought to take into account their own times, their own needs, and their own goals of education when they talk about the claims of classical education. Latin was not still the primary language of literary and diplomatic Europe and America during the Gilded Age, thus it was not an educational necessity. In other words, the needs of the Gilded Age were not the same needs as those of the past when Latin and Greek were essential for an educated individual. Edward Livingston Youmans reiterated this notion, writing, "the system of culture which prevails in our higher institutions of learning, and which is limited chiefly to the acquisition of … the ancient languages and literature, was shaped ages ago in a state of things so widely different from the present, that it has become inadequate to existing requirements."[61] Youmans would have agreed that the acquisition of classical languages was appropriate for education in the past, but he was concerned with education in the Gilded Age. Youmans understood that the classical curriculum was established by long-dead men who had no idea what the needs of Gilded Age (or even nineteenth century) students would be, and that it was therefore high time to rethink what was being taught in the schools, tailoring education to the needs of the present.

[60] Smith, "Classical and Modern Culture."
[61] "Mental Discipline in Education," 2.

Another argument against the classical curriculum was that it did not teach the *existing* state of knowledge, rather it left out the last roughly fifteen centuries of knowledge. According to Youmans, "since its establishment the human mind has made immense advances; has changed its attitude to nature and entered upon a new career; that realm after realm of new truth has been discovered; that ideas of government, religion, and society have been profoundly modified, and that new revelations of man's powers and possibilities, and nobler expectations of his future, have arisen."[62] In other words, the world had changed in the intervening centuries, and presumably so should education. By conceding to the educational plan of the past, the immense increases in knowledge gained by mankind were being neglected, and this must have seemed irresponsible to many educational reformers. According to William Whewell, an influential Gilded Age scientific polymath, a modern education should include knowledge from each of history's "great epochs of mental energy."[63] What Whewell meant here was that knowledge was progressive and accumulative, and that the knowledge of the Gilded Age was built upon the knowledge of past ages. What was most important about neglecting history's great epochs of mental energy was that *science* was being omitted; science was the missing piece of education – the existing state of knowledge in the end of the nineteenth century certainly included science (and, of course, a whole host of other things such as modern languages, advanced mathematics, English literature, etc.).

The scholars in *CDML*, however, did *not* exclude science. Instead, as the quote by Thomas Henry Huxley, the authoritative Gilded Age advocate of the theory of evolution, that opens this chapter states, science was a defining characteristic of the time period, and it was a lynchpin of modern life. More importantly science was *the* all-important subject under

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[62] Ibid., 2.
[63] "Educational History of Science," 229.

discussion. In a supremely quotable passage, Huxley wrote, "The modern world is full of artillery; and we turn out our children to do battle in it, equipped with the shield and sword of the ancient gladiator."[64] What he meant was that while the modern world was permeated with science, students were only taught Latin and Greek, essentially giving them no useful skills or knowledge with which to face the modern scientific world in which they lived. Edward Livingston Youmans rattled off a list of societal issues that a knowledge of science could help – the perils of misgovernment, the limits of legislation, the management of criminals, the operation of charities, the philosophy of philanthropy, the relations of sex and race, international ethics, freedom of trade, the rights of industry, the property of ideas, public hygiene, and the rights of invention to name a few.[65] He pointed a finger at classical scholars whom he claimed were shrinking from these issues by focusing on the past; more useful and responsible would be an education that included science. In fact, by assuming that an understanding of science could help rectify such a broad range of societal issues, Youmans points to the reality that science had permeated life and was a defining characteristic of his times.

In summary, the fundamental argument being explored in this chapter is that the curriculum needed to be modernized and brought up-to-date to meet the needs of the Gilded Age. The basic line of reasoning here was that an education based on the past was obsolete; an educational system based on sixteenth century English modes (which itself was based on the knowledge of fifteen centuries ago) was simply not appropriate in the modern day. Educational decisions should be made by men of the present, particularly as each age has its own needs and knowledge. Furthermore, a good educational system should teach the existing state of knowledge, and the existing state of knowledge most certainly included science; ergo, science

[64] Huxley, "Study of Zoology," 144.
[65] "Mental Discipline in Education."

should be taught in the schools. By looking at other Gilded Age literature, we see that the basic argument laid out in *CDML* was both a product of the times and was an accurate portrayal of other intellectual discourse of the time.

Modern Knowledge as Seen in Other Literature

Antiquated Curriculum and Defiance of Tradition

Charles Eliot, Harvard's president during the Gilded Age, felt it was necessary to redefine liberal education due to "the general growth of knowledge and the rise of new literature, arts, and sciences during the past two hundred and fifty years."[66] Like those scholars found in *CDML*, Eliot saw the value of reforming education in order to meet the needs of the present and also to include the knowledge of the present times. Redefining liberal education meant, of course, revising the powerfully rooted classical curriculum. Because the inclusion of science in the secondary school curriculum necessitated a lessening of the primacy of the classical curriculum, the scientists found themselves in the position of challenging the superiority of classical learning. Perhaps the most straightforward argument against a classical curriculum was that Latin and Greek were dead languages – they were no longer spoken or written languages. (This dictum did not reflect scholarship in those languages, but rather cultural or societal use.) More than this though, the connotation was that a *dead* language was obsolete, disused, defunct, dead. Studying the dead languages was characterized as "the pursuit of graveyard meditations."[67] While Latin and Greek may not have been spoken or written languages in the Gilded Age, the translation of the ancient Roman and Greek literature in order to gather the knowledge of the ancients was often a valid reason for continuing to teach these languages. Not everyone agreed with this sentiment though, and according to at least one Gilded Age scholar, there was "nothing

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[66] *Educational Reform*, 89.
[67] Oswald, "Educational Reform," 203.

new to be learned from the dead languages, all of the useful books being already translated."[68] The obsolescence of the classical languages was in contrast to other subjects like science that were full of vitality and progress, where new knowledge was being generated in the present. The notion of disused knowledge was carried over to another arguing point, namely that knowledge of the classical languages was useless to one's work life. Even those who were classically educated never made use of their knowledge of Latin and Greek in their lives. Latin and Greek would not be used in the office, managing one's estate, directing a bank, or working in a shop, thus the knowledge would eventually be forgotten, falling into disuse.

It is understandable that scientists would feel troubled by the teaching of dead languages at the expense of knowledge gained since the time of the ancients, but it is surprising to find that even classicists were concerned by this fact. Joshua Jones was one such classicist, writing, "The classical system of education was introduced before modern science and literature took their rise… it takes no cognizance of the vast mass of new facts, principles, and ideas which have been added to our stores of knowledge in modern times."[69] While even classicists could admit that much knowledge had been gained since the middle ages when the classical curriculum was introduced, Jacob Bigelow, a Gilded Age professor of both medicine and botany at Harvard University, might have been a bit overdramatic in saying that the amount of knowledge in 1865 was tenfold what it had been at the turn of the century (and presumably a hundred fold what it had been in the times of ancient Greece and Rome, if one follows Bigelow's line of reasoning).[70] Whatever the amount of new knowledge generated since the time of the ancients, the simple fact was that the knowledge of the human race had greatly increased since the time of the ancients, and it ought to be included in the curriculum.

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[68] Paine, as cited by Winterer, *Culture of Classicism*, 43.
[69] "Classical Study," 56-7.
[70] *Limits of Education*.

In reality, the continuance of the classical curriculum was based on something called the "theory of habit," where there was a "prejudice in favor of ancient customs and habitudes, which inclines to a continuance of them after the circumstances which formerly made them useful cease to exist."[71] Herbert Spencer, a prominent Gilded Age scientist, philosopher, and contributor to the theory of evolution, gave some insightful reasons why there was still a prejudice in favor of a classical curriculum. He cited such things as conformity to public opinion, where "men dress children's minds as they do their bodies, in the prevailing fashion," the desire not to look ignorant of the classical languages, and the notion that a classical education would bring applause, honor, respect, and social position and influence.[72] The staying power of the classical curriculum was also due to its social prestige. Jacob Bigelow likened the prestige that a classical education could bring to the Catholic religion in Europe, where they both enjoyed a "shield of impenetrability, and a veil of reverential awe."[73] What Bigelow meant by these words was that a classical education brought with it a reverence and prestige that had been thoroughly established throughout many generations in Europe. Unfortunately for the scientists who were challenging the classical curriculum, they may have felt the reality of this shield of impenetrability.

Other circumstances that helped to entrench the classical curriculum included the advocacy of classically educated men, the desire of teachers to teach it (most likely because the classics were what they themselves had learned and was what they had taught throughout their teaching careers), and the inclination for parents to want their children to learn in school what they themselves had learned.[74] In addition to this, Kim Tolley, a modern day historian of science education, has indicated that the lack of scientific jobs (e.g., careers in geology, botany, physics)

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71 Cloyd, *Benjamin Franklin,* 33.
72 *Education*, 7.
73 Bigelow, *Classical and Utilitarian Studies*, 22.
74 Eliot, *Educational Reform*.

was an influential factor in the inability of science to dislodge the classical curriculum.[75] Finally, Joshua Jones wrote that the classical system had prevailed for so long because if it were to be eliminated, the entire system of thought and social culture of the middle and upper classes would go into a great shock.[76] In Jones' line of reasoning, the classical curriculum had been perpetuated basically as a preventive measure – maintaining the status quo for the sake of maintaining the status quo (i.e., to not rock the boat of education and thus society). Jones' statement exemplifies the shield of impenetrability mentioned by Jacob Bigelow above, where classicists felt that their subjects were so prestigious and vastly important that they held the fabric of society together, much like the Catholic Church in Europe saw itself.

Education in a Democracy

Importantly, Gilded Age scholars were tired of bowing down to antiquity when it came to deciding what should be taught in the schools. The "tendency to exalt the past at the expense of the present" was a common concern of reform-minded intellectuals.[77] Looking to the present and the future was seen as more appropriate than looking to the remote classical past to answer modern day education issues. Deferring authority to the ancient past sacrificed the needs, ideas, and decision-making roles of the present. Jacob Bigelow stated this notion quite succinctly when he wrote, "It is the duty of educational institutions to adapt themselves to the wants of the place and time in which they exist."[78] The conviction among the scholars whose ideas have informed this discussion was that decisions of policy (educational in this case, but the notion can apply to all decisions involving policy) should be made for the present circumstances by men of the present. One of the more noteworthy aspects of the present (i.e., the Gilded Age) was that it was

[75] "Science for Ladies."
[76] Jones, "Classical Study," 48.
[77] Spencer, *Education,* 281.
[78] *Limits of Education*, 23.

a democracy. This was quite different from the constitutional monarchy of sixteenth century England where the classical curriculum found its foothold.

Referring to the issue of education in a democracy, Jacob Bigelow wrote that it was a time of great change, when "the world is resting its future hopes, and quieting its future fears in reliance on a educated and enlightened democracy."[79] As an educational reformer, Bigelow recognized that dealing with the issue of education in a democracy was a significant aspect of improving the educational system. In ideology, a republican government is a representative democracy, a government of the people and for the people. As such, citizenship roles in a republic require duty and responsibility for decision-making. Theodore Sizer's mid-twentieth century history indicates that nineteenth century Americans held the common belief in the need of an educated citizenry in a republic.[80] Herbert Spencer was also aware of the issue of education in a democracy, writing that one of the utmost functions of education was to prepare children for their citizenship roles.[81] In a similar sentiment, Daniel Quinn, a Gilded Age educational reformer, suggested that the duties of education and educators was "almost oppressively important" because they played a vital role in the development of citizens whose responsibility it is to decide questions of the highest import.[82] In an ideal democracy, citizens should be able to form judgment free of personal bias since they have to settle important problems.

Accordingly, an education that included science would help citizens in a republic fulfill some of their duties. Karl Pearson, a noted Gilded Age statistician whose book *The Grammar of Science* influenced Albert Einstein, felt that citizens did not have sufficient impersonal judgment, accurate insight into facts, clear thinking, and responsible judgment skills because they had never

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[79] Ibid., 23.
[80] *Age of the Academies.*
[81] *Education*.
[82] "Higher Education," 15.

learned science.[83] Scientists felt that many of the roles of citizenship and government could benefit from an education that included science. It might seem somewhat of a stretch to claim that science could aid in one's citizenship duties, but scientists like Daniel Quinn and Sir David Brewster, a Gilded Age Scottish scientist, gave some concrete examples of this point. Brewster felt that politicians needed some science knowledge because they might need to make policy decisions that either directly involved science (e.g., questions of public electricity) or required knowledge of science to make the decision (e.g., questions of public health). Science education was valuable to these law makers and statesmen because these were the men who "preside over the life and death of the nation, - who make its laws and direct its battles." Furthermore, judges and juries needed scientific knowledge to make decisions, particularly those where "the verdict rests either upon the ignorance of the judge, or upon erroneous appreciation of scientific testimony."[84] Apparently piracy of intellectual property and patent rights was a troubling and recurrent occurrence at the time that Brewster wrote (i.e., 1867), and it was these issues that he was addressing by giving the examples above. Going beyond lawgivers, statesmen, judges, and juries, Daniel Quinn gave a list of other men who would benefit from science education because they "mould or influence public opinions, habits, [and] morality."[85] Included in Quinn's list (besides those mentioned above) were clergymen, lawyers, physicians, literary men, inventors, scientists (although it would seem obvious that scientists had knowledge of science, and thus an unnecessary part of this list), and businessmen. In fact, Brewster's and Quinn's concrete examples made a cogent case that science education would benefit people in their citizenship roles.

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[83] *Grammar of Science.*
[84] Brewster, "Opening Address," 179.
[85] "Higher Education," 16.

In a democracy where equality is an important principle, the perceived elitist nature of classical studies was a point of contention. In the mind of the typical citizen, all citizens in a democracy have universally recognized freedoms and liberties as well as equal access to power – in other words, equality is a major tenet of a democracy. In a democracy, education should not be class-based. To many, the classics meant an elite, high culture, and a classical education did not meet the needs of the majority of students. An article in the *New York Times* suggested that a classical education prepared boys only for a life of "elegant and cultivated leisure."[86] Thomas Henry Huxley, lamenting the elitism of classical learning, claimed that even individuals deeply educated in other subjects were not permitted into the "cultured caste."[87] Only those classically educated (whether well-educated or not) were supposedly cultured. In his twentieth century analysis of the topic, Richard Hofstadter wrote that nineteenth century Americans felt that a classical education was a manifestation of the arrogance or narcissism found in the morally corrupt.[88] The impression that a classical education was only meant for an elite group, particularly a superior group, contradicted the principle of equality in a democracy. This contradiction was favorable for the scientists' argument, since they were challenging the classical curriculum themselves. What, however, did the classicists have to say about education in a democracy?

Caroline Winterer, a twenty-first century historian, gave some insight into the classicists' take on education in a democracy. She wrote that classicists argued that scientism and the utilitarianism that resulted from it would devolve into an aloofness from the roles of citizenship.[89] In other words, science would hinder people in their citizenship roles by making

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86 "Science and the Classics," 4.
87 *Science and Education*, 142.
88 *Anti-Intellectualism*.
89 *Culture of Classicism*.

them care more about pragmatic actions and outcomes than about principles and ethics in their citizenship roles. Winterer clarified her point by writing that classicists argued against science education (or rather the utilitarianism and materialism that a non-classical education would surely bring) because in a democracy, where the majority make decisions, utilitarian needs should not be deciding factors. In other words, the best way for a democracy to work, a democracy in which the majority are able to fully participate in the process to make decisions, is to educate them classically so that they will make the best decisions (i.e., decisions not based on utilitarian and material factors).

The perceived elitism of a classical education in a democracy was sometimes juxtaposed with conditions in Europe. Richard Hofstadter wrote that those opposed to the classics (not necessarily in favor of science education, rather simply those opposed to the classics) felt that a classical education was suitable only to aristocrats and the people of a European past.[90] Lawrence Cremin, in his mid-twentieth century educational history, had a different take on aristocracy. He interpreted the American sentiment on the traditional classical education of Europe as archaic and of scant use to a democracy led by a "natural aristocracy."[91] A more utilitarian education would evidently be more suitable to create this natural aristocracy, a ruling class based on talent and learning, not birth. Henry Brooks Adams, a member of the renowned Adams political family, gave some insight into the minds of post Civil War Americans who were his contemporaries. He wrote that they wanted to create a world of their own, not to be told what to do and how to do it by "men who took their ideas and their methods from the abstract theories

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[90] *Anti-Intellectualism.*
[91] *National Experience*, 250. It is worth noting that Cremin was referring to the Revolutionary period in America. It would seem, however, that the sentiment he described was, as shown by the other evidence cited in this section, in full force a century later.

of history, philosophy, or theology."[92] While Adams was not necessarily speaking out against a classical education (or necessarily advocating specifically for a science education), he did capture the sentiment that Americans wanted to get out from under the spell of old European ideas and ways, or, as Lawrence Cremin wrote, "reject historic (and corrupt) European values, manners, and institutions."[93] Again, the American desire to eschew the classical curriculum, merely because it was a holdover from their European past, was a favorable condition for the scientists who were questioning the classical curriculum.

Jacob Bigelow was of a somewhat different mindset when it came to the classical European education. He wrote that after the devastation of the Civil War, "we have a Pacific Railroad to be built and a nation to be reconstructed…we may safely leave to our trans-Atlantic friends the leading glory of farther investigating and expounding the classics."[94] Essentially Bigelow was unconcerned with the elitist nature of the classics or with education in a democracy; rather, his belief was that the classics should be left to the Europeans, since there was a nation to build over here in America. Significantly, science education would be a necessary aspect of a nation building railroads and such.

The Needs of the Gilded Age

Both classicists and scientists agreed that a classical curriculum was appropriate in certain times in certain places. The issue at hand was whether or not it was appropriate for America and the United Kingdom during the Gilded Age. The issues surrounding education in a democracy would point to the unsuitableness of the classical curriculum for the needs of the Gilded Age. Various other factors, which will be explored in the coming sections of this research, pointed to the same conclusion. With that said, it is only fair to briefly look at the

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[92] *Education,* 239.
[93] *National Experience,* 265.
[94] *Classical and Utilitarian Studies*, 53.

appropriateness the classical curriculum held at certain times. After all, it is worth understanding the needs and intentions of our educational predecessors.

Charles Eliot gave educational reformers crucial insight into the origins of the classical curriculum. He wrote that it took two hundred years for Latin and Greek to displace metaphysics and theology in the schools, and that this displacement required tedious struggle by educational reformers. His point was important for those advocating for displacing Latin and Greek with science in the Gilded Age. He said:

> The revived classical literature was vigorously and sincerely opposed as frivolous, heterodox, and useless for discipline; just as natural history, chemistry, physics, and modern literature are now opposed. Precisely the same arguments were used by the conservatives of that day which are brought forward by the conservatives of to-day, only they were used against classical literature then, while now they are used in its support.[95]

Interestingly, Eliot seems to have been the only Gilded Age scholar involved in this discourse who picked up on this point, that new learning has repeatedly needed to force its way into the curriculum and argue against a conservative opposition.

The classical curriculum did, in fact, meet the educational needs of people from various time periods. Renaissance Humanists in the fourteenth and fifteenth centuries began a revival of learning, bringing Europe out of the Dark Ages. They rediscovered the written works of the ancient Greeks and Romans, and their resulting curriculum reflected their newfound interest in the classical languages. Elmer Wilds, an educational historian from the 1930s, wrote that the first classical curricula emphasized knowledge of the institutions and ideals of the Greco-Roman world but soon morphed into a Ciceronianism that emphasized style and sentence construction of

[95] *Educational Reform*, 95.

Latin and Greek literature.[96] The first classical curricula that emphasized the literature and beauty and ideals of the Greco-Roman world met the needs of the early Renaissance, as scholars were only beginning to rediscover this past world and its culture. As the Renaissance progressed and the classical curriculum expanded, educational needs changed as scholars needed to correctly understand sentence structure and style in order to correctly translate the literature of the Greco-Roman world.

The classical curricula that resulted from the Renaissance dominated classical learning through the Reformation and the Enlightenment, where Latin and Greek met the needs of those periods in Europe and the United Kingdom. At that time Greek and Latin were living languages. According to Joshua Jones, Latin and Greek encompassed the "only philosophy, history, poetry, and oratory worthy of the name."[97] In other words, a classical curriculum was necessary in order to read, write, and be an educated individual. In the seventeenth century, Latin was still a necessary part of education because it was the language of religion in the Protestant churches, where sermons were read in Latin and Bibles were written and read in Latin; Latin was the sole language of universities; it was the sole language of scientific discussion; and there was no real English literature to speak of (i.e., if one wanted literature, it had of necessity to be Latin).[98] Furthermore, the three primary learned professions of the times, law, medicine and theology, required an education in the classical languages. The law profession required knowledge of the classical languages to read old legal documents and study the greatest works of jurisprudence; the medical profession required it to read the ancient medical writers such as Hippocrates and to understand technical medical terms; and the theology profession required it to read the New Testament and other great works of theology. Accordingly, classical learning was appropriate

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[96] *Foundations of Modern Education*.
[97] Jones, "Classical Study," 6.
[98] Wilds, *Foundations of Modern Education*.

and met the societal and intellectual needs of Europe from the Renaissance up until the Industrial Revolution, when science became a greater educational need.

It is outside the scope of this research to chronicle or explore the origins of the classical curriculum in depth. Others have done this, and the important thing for this research is the understanding that a classical curriculum did serve the needs of certain societies at certain times in the past. Joshua Jones got to the heart of the matter when he wrote, "while it is easy to account for the commanding position which classical studies have so long held in our educational system, the real question for us to decide is, how far that position is at the present time tenable. For it must be remembered that the circumstances of our age are very different from those of the sixteenth century."[99] It is worth noting that these words came from the mouth of a classical scholar during the Gilded Age, and that it was in the first essay in a collection of essays (much like *CDML*) entitled *Classical Study: Its Value Illustrated by Extracts from the Writings of Eminent Scholars*. Interesting indeed that even the classical scholars themselves were questioning the value of their curriculum and admitting that the times and thus needs of society had changed.

Henry Adams, more than most, saw the truth in the need for change. He wrote, "The generation that lived from 1840 to 1870 could do very well with the old forms of education; that which had its work to do between 1870 and 1900 needed something quite new."[100] Adams felt that life and society had changed considerably enough to warrant a change in education. Herbert Spencer also valued the need for educational change, reminding us that, "The question which we contend is of such transcendent movement, is, not whether such or such knowledge is of worth, but what is its *relative* [italics in original] worth… There is perhaps, not a subject to which men

[99] Ibid.
[100] *Education*, 26.

devote attention that has not *some* value."[101] Spencer expressed wisdom when he said that all subjects have some educational value, but his point was that scholars should determine the value of subjects by looking at the needs of their own present times.

According to two twentieth century historians, Gilded Age needs included an education that focused on the immediate, concrete, and scientific because society was increasingly this-worldly, commercial, and optimistic.[102] The needs of the Gilded Age were decidedly scientific in nature. Thomas Henry Huxley validated this, writing, "modern civilization rests upon physical science."[103] Charles Eliot also felt that the Gilded Age was an age of science, writing that the educated world had accepted scientific inquiries as the "only true inspiration of research in all departments of learning."[104] John Gregory, a theologian of the Gilded Age, wrote that during the Gilded Age the men of brawn had yielded to the men of brains, and that the victories of microscopes and crucibles were outstripping the victories of the gun and cannon.[105] One supremely important aspect of the scientific nature of the Gilded Age was Charles Darwin's and Herbert Spencer's work on the theory of evolution, which had pervaded Gilded Age thought. John Fiske, a Gilded Age intellectual, went so far as to say, "There is no subject…that has not come to be affected by the doctrine."[106] In fact, Fiske felt that it was a permanent acquisition of people's mindset by the turn of the century. As detailed in the introduction, the Gilded Age unquestionably was a time of science. And likewise, science was the missing piece in the modern day educational system.

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[101] *Education*, 13.
[102] Cremin, *National Experience*; and Sizer*, Age of the Academies*.
[103] "Study of Zoology," 144.
[104] *Educational Reform*, 70.
[105] *Sciences and Arts.*
[106] *Century of Science*, 49.

The Purpose of Education

Of course, any educational reform discourse should deal or have dealt with the fundamental question of the function of education. According to Herbert Spencer, the only function of education was to prepare students for complete living (which included direct self-preservation, indirect self-preservation, parenthood, citizenship, and the miscellaneous refinements of life, in that order).[107] In his analysis of the time period, Lawrence Cremin revealed that education was increasingly used as an instrument for personal advancement and social improvement rather than for its own sake.[108] While Spencer and Cremin indicate that both individual and social aims of education were considered during the Gilded Age, immediate individual aims of education often clashed with ultimate social objectives of education. Elmer Wilds indicated some other discordances that have played a part in the history of education including education for indoctrination for conformity versus education for original thinking and progress; selective versus universal education; practical versus theoretical education; and education for applying knowledge versus education for erudition or education for its own sake.[109] Not all of these discordances were manifest during the Gilded Age in the discourse about science education, but there certainly were some fundamental clashes.

One such clash was manifested in the foundational debate between education to train and develop the mind and education to impart knowledge that could be directly used in later life. The classicists professed that the aim of education was preparation to acquire knowledge – not to impart information but to exercise and develop the faculties; not to store knowledge but to

[107] *Education.*
[108] *National Experience.*
[109] Wilds, *Foundations of Modern Education*.

stimulate the desire of and power to acquire it; not to train for a future job but to fit boys for all jobs.[110] Here education is individual, theoretical, and academic.

In fact, it would seem that the classical curriculum met immediate individual aims of education more than social objectives of education. Mental discipline (under its many guises of training the mind, developing the faculties, exercising the intellect, etc.) was *the* status quo purpose of education. Imparting knowledge, particularly knowledge that could be directly used in life outside of school, was an educational goal of some that was an alternative to the status quo educational goal of training and developing the mind. With that said, these two alternatives were not mutually exclusive, and often those advocating for teaching science in the schools professed that science could both train the mind *and* impart useful knowledge and training. In fact, many of the scholars in *CDML* claimed that training the mind was the purpose of education, and they tailored their discourse around that assumption.[111] The underlying argument about the purpose of education is important to the discussion here, for this is where the debate between the classicists and the scientists raged most heavily.

Classicists versus Scientists

Robert Quick, a Gilded Age educational reformer, gave additional insightful designations for the groups forming the "sides" of this debate. He wrote that *Humanists* were those who wished to educate via a study of the classics, and *Naturalists* were those who wished to educate via the study of the works of nature.[112] Since, however, the intellectuals absorbed in the debate during the Gilded Age were more simply, as professionals, either classical scholars or scientists,

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110 Taylor, *Classical Study*; and Jones, "Classical Study."
111 For example, see Barnard, "Early Mental Training;" Henfrey, "Study of Botany;" Herschel, "Extracts;" Huxley, "Study of Zoology;" and Youmans, "Mental Discipline in Education."
112 *Educational Reformers*. In addition to Humanists and Naturalists, Quick mentioned *Realists*, or those who felt education should be independent of study and knowledge, rather that one's character should be trained and the Greek ideal of beauty and goodness should be attained. Realists do not play a part in the discussion above, however.

these terms will be used here. A *New York Times* article from the time period reminds us that prior to the middle of the century the debate was between ancient literature scholars and modern literature scholars.[113] It was only during the Gilded Age that scientists joined in the debate, thus pitting literature against science.

Inasmuch as it would be an entire dissertation unto itself to delve into the depths of the debate between the classicists and the scientists, a few of the more prominent lines of discourse will be examined here.

The classicist case frequently rested on the virtues of a classical education – not what other subjects could or could not do, but all of the superior things a classical education could do. Education and instruction in the classical languages was *the* path to culture and liberal education. One who had no knowledge of Latin and Greek simply was not an educated individual. Moreover, knowledge of the ancient languages was *the* definition of scholarship and learning. This reputation and prestige was, for a long time, a very powerful bastion against foes, and it was a ready go-to argument for the classicists to use to defend their curriculum.

Latin and Greek were, according to the classicists, the two most perfect languages known to mankind, making them the best subjects for disciplining the mind and training it in exact thought.[114] Latin and Greek were the study not only of perfect languages, they were also the study of human nature.[115] Studying human nature would certainly fit in as an immediate individual aim of education (as opposed to broader social aims), revealing that the classicist argument was both geared toward individual aims of education and an education that trained the mind.

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[113] "Science and the Humanities."
[114] Harris, "Study of Latin and Greek."
[115] Ibid.; and Taylor, *Classical Study.*

In terms of other individual aims of education, classicists claimed that the classics refined one's taste, humanized one's manners and conversation, and maintained the moral life of mankind.[116] Finally, in a more academic bent, the classicists could claim for their curriculum that it laid the most solid foundation for every other part of learning, as ethical, political, oratorical, and artistic ideals were structured by ancient Greece and Rome, and particularly as modern medicine, anatomy, and physiology had a great debt owed to the ancient Greeks.[117] In fact, some classicist arguments did directly address science in the curriculum. Some classicists made their argument for the classics by embracing science, reckoning that scientists should learn the classics since scientific names were universally expressed in either Latin or Greek.[118] Other classicists addressed science in the curriculum in a derisive way, writing that science can only hope to cultivate one faculty (which, by the way, was never specified) while the classics cultivated them all at once. Samuel Taylor, one classicist, wrote, "Whatever the value of science, it is not indispensible, for I am wholly ignorant of it."[119] While this point may have been valid for any number of successful men, the argument by the scientists was that science *was* indispensible in a reformed curriculum in which the existing state of knowledge was taught.

The practical aim of education of imparting knowledge was derided by at least one classical scholar who wrote, "The fact that there is a vast store of knowledge in the world is no more reason why I should acquire it all, than the fact that there is an immense store of food is a reason why I should eat it all."[120] Apparently imparting knowledge rather than training the mind was seen, at least by Joseph Payne, as something nearly as sinful as gluttony.

[116] Taylor, *Classical Study*.
[117] Ibid.; and Winterer, *Culture of Classicism*.
[118] Martin, "Classics in Education."
[119] Taylor, *Classical Study*; and Wilson, "Natural Science in Schools," 259.
[120] Payne, "Classics and Science," 163.

For their part, the tone of the scientists' arguments was often apologetic to the classics. Thomas Henry Huxley wrote such things as, "Do not expect me to depreciate the earnest and enlightened pursuit of classical learning. I have not the least desire to speak ill of such occupations," and "I shall be profoundly sorry to see … to starve or cripple literary or aesthetic culture for the sake of science."[121] In essence the scientists were not disputing that the classics deserved a place in the curriculum, simply that it ought not to occupy the central place in education. In reality, it seems like they did not want to bite the hand that fed them, so to speak. They probably had to be a bit apologetic and delicate when speaking about the classics, since it was the entrenched status quo of education – a big hill to climb, made possibly less steep by gaining the goodwill of the classicists (or at least not drawing their ire).

Richard Hofstadter would probably have considered any argument by the scientists as "anti-intellectual," for he wrote that during the time period there was a pervasive anti-intellectual American outlook that can be characterized by a widely shared contempt for the past, the opinion that the past was despicably impractical, and the mindset that the past was nothing more than something that needed to be surmounted.[122] The discourse of scientists in the Gilded Age was certainly intellectual since they were producing and disseminating ideas and participating in discussions about education. In fact, my point is not that the scientists and their discourse were anti-intellectual – actually the opposite, they were vastly intellectual. My point is two-fold – firstly, Hofstadter would possibly characterize the scientists and their discourse as anti-intellectual simply because it was a counter to the supremely intellectual culture of classical education; and secondly, that while the scientists and their discourse were not anti-intellectual, it

[121] *Science and Education*, 97, 162.
[122] *Anti-Intellectualism*.

is possible that the classical scholars themselves interpreted the discourse as anti-intellectual and felt that the scientists themselves were anti-intellectual.

Liberal versus Conservative

The discourse between scientists and classicists exemplifies the quintessential battle between progress and tradition. In other words, this was a clash between liberalism and conservatism. While definitions for liberalism and conservatism will never satisfy everyone, and while a definition for these terms will never be static, we can discern some aspects of these two camps from the Gilded Age and how each played out in the discourse.

Vincent Falcone, a late twentieth century educator, gave a nice short guide to the two terms liberal and conservative. Overall, a liberal sees change as necessary and a positive good and thinks that things can be better than they are now, while a conservative is relatively satisfied with the way things are, is skeptical of change, preferring tried and true methods of advancement. Liberals believe in the perfectibility of man, while conservatives believe that man is imperfect and imperfectible. Liberals believe in the need for experiment, change, and reform, while conservatives believe in order and tradition, taking a pessimistic view of change. Liberals look to the future and place their hope there, while conservatives look to the past, believing that things were better in former times. Liberals believe that man is good and that society is the culprit, while conservatives believe that man has a flawed nature.[123]

Scholars of the Gilded Age did not necessarily use the terms liberal and conservative (or at least not the term conservative – the term liberal was bandied about by some), but their ideas can fit in to our modern day notions of Gilded Age liberalism and conservatism. In fact, Vincent Falcone's characterizations, while commendable, were not written with the Gilded Age in mind. Other twentieth century scholars have, however, given us some insight into what the terms might

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[123] *Great Thinkers.*

have meant in the last part of the nineteenth century. Richard Hofstadter, as mentioned above, would probably categorize anti-intellectuals as liberal, particularly during the Gilded Age when, he claims, there was a pervasive fear of the mind (i.e., fear of intellectuals), disdain for culture, contempt for the past, and blinding reverence for an unknown future.[124] Louis Menand, a twenty-first century historian, indicated that liberalism implied an opposition to the reproduction of political, social, and cultural hierarchies.[125]

Conservatism, on the other hand, entailed development of self-knowledge, self-control, and self-expression; it was in opposition to pursuits that brought wealth or skill or fame (i.e., practical pursuits); and it was in opposition to the crass materialism of industrial capitalism.[126] Classicists of the Gilded Age would have been conservatives, as they looked to the past, "as a way to combat such cancers of modernity as materialism, civic decay, industrialization, and anti-intellectualism," as well as corruption, factionalization, and populist mediocrity.[127]

In terms of education, William Lowe Boyd, a twentieth century educator (in no way referring to the discourse of the Gilded Age) reminds us that one of the fundamental issues in regard to educational reform is, "whether the curriculum will be used in an attempt to maintain or change society."[128] Old ideas and the status quo belonged to the classicists, and their conservative bent meant that tradition and ritual were on their side. New ideas and an attempt to reshape society via education belonged to the scientists, and their liberal bent meant that they took an optimistic view of change and felt that man was good and that society was to blame.

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[124] *Anti-Intellectualism.*
[125] *Metaphysical Club.*
[126] Winterer, *Culture of Classicism.* Winterer does not use the term conservative, rather she uses the term "liberal culture" when describing the things above, but for the sake of simplicity here, these things can be seen to be conservative in nature.
[127] Ibid., 4.
[128] "Changing Politics," 577.

As for the discourse coming out of the Gilded Age itself, the terms *progress* and *past* would be more apt than liberal and conservative. Jacob Bigelow called the classics stationary and science progressive; Robert Quick called the literary spirit a reverence for the past and the scientific spirit a disdain for the past; he also wrote that the Golden Age was no longer in the past but must now always be in the future.[129] Thomas Henry Huxley, in a clearly liberal state of mind, wrote, "The Nemesis of all reformers is finality," placing his hope in the future, reform, and change.[130] Edward Livingston Youmans had a fairly liberal tendency himself, writing about the classicists and scientists, "while the one looks forever backward, the other leads steadfastly forward."[131] Finally, John Tyndall, in quintessentially liberal rhetoric, wrote, "it would be treason to the trust committed to us, if we were to sacrifice the hopes and aspirations of the Present out of deference to the Past."[132]

While the above analysis of Gilded Age scholars would tend to indicate that the sole difference between liberals and conservatives (or rather scientists and classicists) was simply that one looked to the future while the other looked to the past, this is not the case. In the first paragraph of *CDML*, Edward Livingston Youmans sets the stage with infinitely liberal eloquence. He wrote:

> "All educational inquiries assume that man is individually improvable, and therefore collectively progressive. Through varied experiences he is slowly civilized, and there is a growth of knowledge with the course of the ages. But while thought is ever advancing, it is the nature of institutions to fix the mental states of particular times; and there hence arises a tendency to conflict between growing ideas and the external arrangements which

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[129] Bigelow, *Classical and Utilitarian Studies*; and Quick, *Educational Reformers*.
[130] *Science and Education*, 149.
[131] "Mental Discipline in Education," 54.
[132] "Study of Physics," 66.

> are designed to express and embody them. Thought refuses to be stationary; institutions refuse to change, and war is the consequence."[133]

Here we see many of the fundamental aspects of liberalism – the improvability of mankind, looking toward the future, change, and progress. He also succinctly encapsulated the liberal versus conservative battle, static in opposition to change.

Modern Knowledge as Relates to Scientific Literacy

As the previous section of this chapter has shown, the discourse seen in *CDML* was both a product of the times and was being echoed in the larger intellectual arena. With that in mind, the discourse in *CDML* is being treated as a representative sample of thought during the Gilded Age. In my analysis of the discourse in *CDML*, I paid special attention to points that may have laid some foundations for our modern day notion of scientific literacy. By analyzing the discourse through a modern day lens of scientific literacy, I can gain greater insight into the discourse, a deeper analysis of it, and a way to organize my thinking about it. For an in-depth review of the current discourse on scientific literacy, please refer to Appendix A. Within the discourse in *CDML*, six scholars embraced the argument to modernize the secondary school curriculum by including science in the curriculum. While not all aspects of their arguments relate to our modern day understanding of scientific literacy, it became clear that certain points made by the Gilded Age scholars are consonant with our current notion of scientific literacy and thus serve as a foundation for the present day discourse.

Social Responsibility

In my review of the modern day literature on the topic of scientific literacy I found that the most widely cited reason given for promoting scientific literacy is for social responsibility. When one's scientific literacy is applied to one's social responsibilities, an understanding of the

[133] "Mental Discipline in Education," 1.

concepts and principles of science is less important than decision-making skills and one's ability to participate in a democracy where scientific issues arise. The defining term for this nuance within the modern day literature is arguably "citizen," with expressions such as "effective citizenship," "productive citizens," "informed citizens," "concerned citizens," "good citizenship," and "citizen science" commonly found.[134] The idea that a good citizen is one who can participate in the democratic process seems fundamental to scholars who advocate for scientific literacy based on social responsibility. In fact, Milton Pella writes that unless the public has an understanding of the implications of scientific development on society, the "democratic process is endangered."[135] Competent participation in the democratic process is therefore one constructive outcome of promoting scientific literacy in the science curriculum.

In section two of this chapter I took a detailed look at the Gilded Age issue of teaching science in a democracy. As conceived by the Gilded Age scholars cited above, citizenship roles in a republic require the ability to make decisions on issues in society. As society was increasingly scientific in nature, decisions requiring some understanding of science would increasingly become necessary, thus laying the foundation for needing scientific literacy. In this case, scientific literacy would promote social responsibility and stimulate citizenship duties. As pointed out above, judges and juries needed scientific literacy to make decisions; lawgivers and statesmen need scientific literacy to make laws; clergymen, physicians, inventors, business men, and scientists all needed scientific literacy because they were responsible for molding public opinion and habits. In effect, all citizens in a democratic and scientific world had some need of

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[134] AAAS, *SFAA,* xiii; and Kolstoe, "Consensus Projects," 645, use the term "citizen." Culliton, "Dismal State," 243; and Miller, "Scientific Literacy," 1, use the term "effective citizenship." Hurd, "Scientific Literacy," 407, uses the term "productive citizen." DeBoer, "Scientific Literacy," 592; and Ewing, Campbell, and Brown, "Improving Student Attitudes," 350, use the term "informed citizens." Eisenhart et al., "Conditions for Scientific Literacy," 285, use the term "concerned citizens." Lee and Roth, "Science and the 'Good Citizen'," 403, use the term "good citizenship." Roth, "Scientific Literacy," 13, uses the term "citizen science."

[135] Pella, "Scientific Literacy," 347.

scientific literacy. The notion occurred in the past and occurs today that citizens in a democracy must have an understanding of science in order to fully and responsibly participate in the democratic process, particularly as scientific issues are often in the public agenda.

Interaction of Science and Society

The interface of science and society is another common thread of modern day discourse on scientific literacy. Morris Shamos calls this "science-based societal issues."[136] The standard argument given for promoting scientific literacy here is for students to be aware of, and be able to respond to, societal impacts of science.[137] Science here is socially relevant and socially situated.[138] Again, knowledge of the facts of science is less important than an understanding about the collective nature of science and the ability to react to public consequences of science.

Edward Livingston Youmans was one Gilded Age scholar who recognized the societal impacts of science and felt that science education could help citizens address these various impacts. His list of societal issues that a knowledge of science could help included the management of criminals, the operation of charities, the philosophy of philanthropy, the relations of sex and race, international ethics, the property of ideas, public hygiene, and the rights of invention to name a few.[139] Youmans placed these various societal affairs in the context of science by saying that modernizing the curriculum to include science would allow people to take responsibility for these issues and deal with them. This was unlike the classical curriculum, which Youmans claimed shirked from such societal issues.

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[136] Shamos, *The Myth of Scientific Literacy*, 77.
[137] Bybee, "Achieving Scientific Literacy;" Culliton, "Dismal State;" Evans, "Scientific Literacy;" Ewing et al., "Improving Student Attitudes;" Hofstein and Yager, "Societal Issues;" Miller, "Scientific Literacy;" and Mitman, Mergendoller, Marchman, and Packer, "Components of Scientific Literacy."
[138] Lee and Roth, "Science and the 'Good Citizen';" McGinn and Roth, "Preparing Students;" Roth, "Scientific Literacy;" and Roth and Calabrese Calabrese-Barton, *Rethinking Scientific Literacy*.
[139] "Mental Discipline in Education."

As opposed to classical learning, which promoted individual benefits and elitist education, science learning promoted societal benefits and a less elitist education. By advocating for more social rather than individual outcomes of science, Gilded Age scholars were laying the foundations for scientific literacy as relates to science and society. The modern day notion that science is socially relevant and socially situated can be seen in the Gilded Age fight against the self-interest and elitist character of the classical education.

Organization of Knowledge

The modern day literature on scientific literacy, particularly *SFAA*, the *Benchmarks*, and the *Standards*, indicates that knowledge and understanding of the basic facts and principles of science (e.g., motion, electromagnetic forces, and cell structure) is one facet of scientific literacy. Likewise, a knowledge and understanding of the basic vocabulary of science (e.g., cardiovascular, centigrade, and genetic) is an equally fundamental facet of scientific literacy.[140] None of the scholars reviewed in the current day literature on scientific literacy would consider the organization of scientific knowledge as the sole purpose or criterion of scientific literacy; rather, the organization of scientific knowledge is merely a necessary component of the scientifically literate person.

While modern day scholars would not consider the organization of scientific knowledge the main purpose of scientific literacy, Gilded Age scholars, on the other hand, *could* be said to have felt that the organization of knowledge of science was a main purpose of scientific literacy. One of the principle arguments in favor of teaching science was that education should teach existing knowledge, and that the classical curriculum stopped at the knowledge acquired by the ancient Greeks and Romans. Scientific knowledge had grown immensely since the time of the ancients, and as we saw above, the argument was that a modern education should include

[140] AAAS, *SFAA*; *Benchmarks*; and NRC, *Standards*.

modern knowledge. In this instance, scientific literacy as the organization of knowledge, or as imparting the major concepts of science, was often the only argument needed in order to advocate for the teaching of science.

Conclusion

To review, the main argument explored in this chapter was that the curriculum of the Gilded Age secondary school, of necessity, should be updated to include science. An education based upon the needs of the past and also based upon the educational system of the ancient past was obsolete and not useful in daily life. Existing knowledge should be taught in the curriculum, and this meant that science should be included in the curriculum. Most importantly, it was necessary to *think* about the educational system and the needs of the present; instead of simply bowing down to the past because that is how things had been done previously, men of the present should decide for themselves what best suited their needs. In fact, the men of the Gilded Age did do a lot of thinking about their educational needs – explored in this chapter were reflections on education in a democracy, where the scientists called for an educated citizenry in a democracy, disagreed with the elitism of a classical curriculum, and looked to the present and future to solve their problems. The scientists of the Gilded Age also thought about the needs of their times, concluding that an education that included science was a definite need. The discourse between the classicists and the scientists was also explored in this chapter, looking at their discourse through the lens of conservatism and liberalism, where the classicists were seen to be conservatives who looked to the past for guidance and put their faith in traditions, while the scientists were seen to be liberals who looked to the future for guidance and put their faith in progress and the improvement of mankind.

Modernizing the curriculum to include science has been shown to have been a major facet of the Gilded Age discourse on science education. Intimately tied to updating education for the modern world was the fact that the modern world was increasingly scientific and education ought to prepare students to live in this scientific world. It is to this notion that we now turn.

It has altered our whole state of existence – one might say, the whole face of the globe. We owe this to science, and to science alone.

Prince Albert, "On the Educational Claims of Science"

CHAPTER 3

FUNCTIONAL EDUCATION

Introduction

This chapter is constructed in a manner that uses the discourse in *CDML* regarding how education should be made more functional as a foundation. This discourse will then be examined and analyzed utilizing other Gilded Age literature and various secondary sources from both the twentieth and twenty-first centuries. As such, in the first section of the chapter the arguments found in *CDML* will be laid out as they appear in that book, with discussion and elaboration being saved for the second section of the chapter. Finally, in the third section of the chapter the Gilded Age discourse will be examined through the lens of our modern day notions of scientific literacy.

In this chapter I explore those arguments relating to making education more functional and utilitarian for the students. Gilded Age scholars were concerned about preparing students to live in a scientific world, where the ability to use scientific ways of thinking in their everyday lives was an important outcome of school. I will explore various topics related to the notion of making education more functional for life outside of school. Included is a discussion on the purpose of education, where training the mind was often set in opposition to other educational outcomes such as conveying useful knowledge and practical skills. The discussion of the purpose of education will also include an investigation of the discourse which presented adverse reactions to making education more utilitarian, particularly discourse from the classicists who adopted an argument of the uselessness of the classics in their arguments. Also examined is the distinction between science and technology, particularly as seen through the eyes of the Gilded Age scholars. Discussions of science and technology are placed in the context of the needs of the Gilded Age, showing that life outside of school was increasingly scientific and thus it was a necessity to prepare students via a scientific education. Finally, I explore the arguments about teaching students to think like scientists, looking at what this meant in the Gilded Age in terms of process skills, reasoning skills, and personality traits.

Functional Education as Seen in *Culture Demanded by Modern Life*

Some schools of thought such as Progressivism believed that it was important for education to prepare students for life after school. As such, a common argument has been that students should gain a functional education that would prepare them for life outside of school, particularly life in a scientific world, and help them to think like scientists in their everyday lives. Of course, for the science-minded reformers of the Gilded Age, teaching science would achieve these aims. In fact, fully half of the scholars found in *CDML* addressed the issue of making educational aims more functional, although functionality was defined in various ways, as will be discussed below. In particular, Edward Livingston Youmans, John Tyndall, a Gilded Age physicist, Frederick Barnard, a Gilded Age president of Columbia University, and Michael Faraday, a Gilded Age contributor to the fields of electricity and magnetism all put appreciable emphasis in their writings on the topic of education that would prepare students for life outside of school.

The purpose of education as conceived in the post Civil War period was discussed in the previous chapter though a brief recap of the argument is worthwhile. The importance of the purpose of education for the argument in favor of a functional education is paramount. This is because the drive to make educational outcomes more utilitarian in nature was, at its root, a struggle against the established purpose of education. Up until the latter part of the Gilded Age, the single purpose of education was to the train the mind; there were no utilitarian outcomes professed for a classical education, and the classical curriculum was what the scientists were questioning. What is interesting about the scientists' standpoint is that they did not dispute the idea that the primary function of education was to train the mind. Even when arguing for a functional education, training the mind was still seen by most as the main purpose of education. Frederick Barnard, whose central claim was that education needed to be more useful, still assumed, and even entitled his oration, that mental training was the purpose of education.[141] The scientists' mindset was that training the mind and achieving other, more functional outcomes, were not mutually exclusive goals, and that science could both train the mind and prepare students for life outside of school. Francis Wayland came right out and stated that any education that could not both increase one's knowledge and also discipline the mind was flawed.[142] Thomas Hill, Charles Eliot's predecessor as president of Harvard University, made an insightful remark to this end about developing mental powers; he wrote, "If education is to develop the mental powers, then those powers must have a legitimate field of exercise. There must be truth that is worth knowing, and work that is worth doing."[143] These authors were suggesting that students would be more interested in their intellectual exercises if there were an actual truth to be attained by the task, but more importantly, separating mental exercise and the learning of actual

[141] "Early Mental Training."
[142] "Modern Collegiate Studies."
[143] "Cultivation of the Senses," 447.

truths was an unnecessary practice. These scholars recognized that education for mental discipline versus education for function was a false dichotomy. Scholars like Francis Wayland invoked the laws of God, writing that God did not intend for there to be two sets of mental machinery, where one trains the mind and the other gives it useful knowledge. Rather, God intended that our mental requirements harmonize with one another, where intellectual benefits would also confer knowledge and vice versa.[144] While it was a strong arguing point in favor of science's inclusion in the curriculum, that educational subjects could both train the mind and confer knowledge, the underlying assumption was that exercising the intellect, or training the mind, was the foremost purpose of education.

"Training of the mind" seems to have been one of those terms used by people to encapsulate their point on either side of the argument. But most users of the term failed to define what they meant by the term. Michael Faraday made a very good point on this topic when he said:

> The phrase, "training of the mind," has to me a very indefinite meaning. I would like a profound scholar to indicate to me what he means by "training of the mind;" in a literary sense, including mathematics. What is their effect on the mind? What is the kind of result that is called "training of the mind"? Or what does the mind learn by the training?[145]

Frederick Barnard was one scholar who did define the term. He wrote that it means "invigorating the mental faculties by wholesome exercise, and … training them to the habits of method in exercise."[146] Unfortunately, this definition comes across to the modern reader as being just as unclear and abstract as using the term with no definition at all. Other terms such as *teaching how to think, disciplining the mind, mental discipline*, and others were used just as ambiguously. In

[144] Wayland, "Modern Collegiate Studies."
[145] "Extracts," 462.
[146] "Early Mental Training," 317.

his excerpt from *CDML*, George Paget, a Gilded Age physician and physicist, talked about training the mind; he meant training in the skills of investigation and learning various aspects of the nature of science.[147] Edward Livingston Youmans, with a different take on mental discipline, defined it as readying students for life outside of school, presumably teaching them to think like scientists in their everyday lives.[148] Sir John Frederick William Hershel, the great astronomer of the nineteenth century, used none of these terms, but he stated that the purpose of education was to form youth for general life and civilized society, by which he meant teaching them to investigate, think inductively, and make generalizations (i.e., teach them how to think).[149] Clearly many different connotations applied to the term training the mind, and it will be shown that some of these were, in fact, utilitarian in nature, where the outcomes of exercising the mind could be useful in one's everyday life.

Scholars fighting for a more functional education had an uphill battle, for it was more than simply challenging the status quo purpose of education. Frederick Barnard gave some insight into what the scientists were really battling against. He mentioned the common axiom which stated that a body of knowledge "which is adapted to educational uses cannot be … of any direct use in the world; and conversely, that a subject which is self-evidently practically useful can by no possibility have any educational use whatsoever."[150] This common adage implied that the classics, because they had been adapted for educational use, were not of direct use in one's life, and that furthermore science, which would have direct use in one's life, consequently could have no educational value. According to Edward Livingston Youmans, utility in education

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147 "Influence of Scientific Culture."
148 "Mental Discipline in Education."
149 "Extract."
150 "Early Mental Training," 335.

actually bordered on being offensive in the minds of some classicists.[151] Knowledge was to be gained for its intrinsic interest, not for useful application. In fact, advocates of the classics as the basis of a good education praised the "glorious inutility" of the classics.[152]

Although the classics were decidedly non-utilitarian, the Gilded Age was a time when utility was needed, and the scientists were ready with various positive utilitarian outcomes of a scientific education. Interestingly, the terms *practical, useful, utilitarian,* and *functional* were, like the term mental discipline, used somewhat ambiguously and interchangeably in the Gilded Age. For my own purposes, I will primarily use the terms functional and utilitarian somewhat interchangeably, with the definition that a functional or utilitarian education would be one where the acquiring of skills and knowledge, in addition to ways of thinking, are educational outcomes. For their part, the scientists in *CDML* did not shy away from using these various terms in their argument for making educational outcomes more utilitarian. Some, like Thomas Henry Huxley and Frederick Barnard, were broad with their words, simply writing that education should be real and practical, since we were surrounded by science in our lives and in this matter-of-fact world.[153] Other scholars from *CDML* gave more specific examples of the functionality of a scientific education. Thomas Hill wrote that knowledge of science would allow one to enjoy life more, such as when out for a walk in nature.[154] Sir Joseph Hooker, a Director of the Royal Botanical Gardens at Kew, England during the Gilded Age, wrote that people routinely came in to the Kew Gardens asking questions about which fibers could and could not be used for making cotton, yarn, paper, and other things. A scientific education, according to Hooker's testimony,

[151] Youmans, "Mental Discipline in Education."
[152] Wayland, "Modern Collegiate Studies," 435.
[153] Huxley, "Study of Zoology;" and Barnard, "Early Mental Training."
[154] "Cultivation of the Senses."

would help people in these types of everyday questions.[155] In a more economic bent, John Herschel was of the opinion that knowledge of nature (i.e., animal, vegetable, and mineral productions) would allow more manipulation of and profit from the earth.[156] Similarly economically minded, Arthur Henfrey, Gilded Age botanist, suggested that agriculture practices would benefit from a scientific education, botany in particular.[157]

Other scholars in *CDML* gave more political and societal examples of the functionality of a scientific education. For example, Herbert Spencer wrote that knowledge of science should form the basis of knowledge of those who control and adjust social processes, namely government representatives and legislators. By giving some fine examples such as that a knowledge of Latin vocabulary is no basis for fixing modern social problems, a knowledge of ancient Greek and Roman battles is no understanding of politics or economics, and the ability to parse a sentence is no foundation for understanding wage determination, Spencer made his central claim that a scientific education was a better foundation for the duties of citizens and lawmakers than a classical education.[158] Socially positive results of a utilitarian science education such as improved agricultural practices were an effective way to argue against the inutility of a classical education. The Gilded Age was less a time of ideology and more a time of action, where a philosophy like pragmatism, which states that meaning is found in the consequences of actions rather than in ideology, found root and prospered. By arguing for utilitarian outcomes, the scientists were, in a way, using a pragmatic line of reasoning.

For the science curricular supporters of the Gilded Age, a strong arguing point for a functional education came in the various skills a scientific education could grant. Present-day

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[155] "Extracts."
[156] Herschel, "University Studies."
[157] "Study of Botany."
[158] "Political Education."

literature on science education and scientific literacy frequently includes scientific manual skills such as using a balance, using a graduated cylinder, drawing a graph or histogram, and writing up a lab report. Gilded Age scholars did not address these kinds of manual skills in their discourse; instead, scholars in *CDML* considered what today are labeled as process skills. Noticing the aspects, properties, and relations of objects, in other words, observation skills, were noted by multiple scholars as necessary skills for living and something that a science education could provide.[159] Other process skills mentioned include classificational skills, coordinating abilities, computational skills, and investigational skills.[160] These process skills were tools that could be used by everyone in their everyday lives, and thus something that a functional education should provide.

For some scholars, the benefits of advocating for the inclusion of curricular science process skills only went so far. For those individuals, the real functional aspect of a science education would be gaining the ability to think like a scientist in one's everyday life. Thus the most powerful point of their argument came down to convincing contrarians that acquiring scientific thinking skills or a scientific habit of mind was not always something entirely different from those thinking skills a classical education could provide. Both sides agreed that thinking skills such as memory, logic, and clarity of language were things a classical education could also provide, but the crux of the scientists' argument was that science could also provide these same skills and more. The critical thinking skills that science, and science alone, at least according to scientists, could provide were inductive and deductive reasoning skills. Multiple scholars used the terms inductive reasoning and deductive reasoning, showing that these terms were clearly in

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[159] Barnard, "Early Mental Training;" Hooker, "Extracts;" Owen, "Extracts;" Tyndall, "Study of Physics;" and Youmans, "Mental Discipline in Education."
[160] Barnard, "Early Mental Training;" DeMorgan, "Intellectual Attainment;" Owen, "Extracts;" Tyndall, "Study of Physics;" and Youmans, "Mental Discipline in Education."

vogue at the time, at least in the world of scientists.[161] Reasoning skills were a significant feature of the scientists' rationalization for teaching science. For example, illogical reasoning, according to Thomas Hill, was just as often a result of inaccurate observation as poor reasoning skills, although improving both observation and reasoning skills would remedy this situation.[162]

While reasoning skills were at the forefront of the scientists' definition of what it meant to think like a scientist, they also included other ways of thinking in their discussion about teaching students to think like a scientist. The ability to form lucid and precise ideas was another scientific habit of thought that would result from studying science.[163] The ability to reason both inductively and deductively coupled with an ability to form articulate ideas would be crucial for constructing sound arguments. This was indeed a necessary skill in the world, according to Michael Faraday, who seems to have been incensed by the inability of persons within society to detect a scientific fraud. Imprecise language coupled with vague claims by hoaxers was, apparently, fooling a lot of people. (This topic will be discussed in detail in the following chapter.) Finally, abstraction and generalization (which themselves are similar to inductive and deductive reasoning) were noted as functional thinking skills a science education could offer.[164] Having the ability to think like a scientist in one's everyday life was so important an argument in favor of a scientific education that this point was brought up over and over again as an aspect to almost all of the main arguments that will be explored in this research. In fact, it may have been the single most decisive argument put forth by the scientists, simply because it addressed many of their concerns such as making education more functional, combating scientific and

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[161] Barnard, "Early Mental Training;" Hooker, "Extracts;" Tyndall, "Study of Physics;" and Youmans, "Mental Discipline in Education."
[162] "Cultivation of the Senses."
[163] DeMorgan, "Intellectual Attainment;" and Faraday, "Education of the Judgment."
[164] Tyndall, "Study of Physics."

medical hoaxery, and facilitating the progress of science itself, all of which will be examined in upcoming chapters.

Gaining an understanding of the nature of science was one additional factor that the scholars collected by Edward Livingston Youmans felt would give students a functional education. Touching on some facets of the nature of science, Michael Faraday wrote that a science education could teach students to draw conclusions from premises, detect a fallacy in reasoning or logic, correct undue generalizations, and correct mistakes of reasoning.[165] While these are habits of thought of scientists, they are more importantly aspects of the nature of science, and they clearly have application in decision making in one's life. John Hershel also talked about teaching students how to think, but his conception of teaching how to think was more in line with teaching aspects of the nature of science. For instance he placed great emphasis on understanding how valid propositions are drawn and the consideration of various facts and circumstances to make decisions.[166] Decision-making by investigating various viewpoints, searching for inverses and opposites, doubting our assumptions, and using imagination were also aspects of the nature of science (and utilitarian skills) that science could teach students. Finally, the ideas that it is improper and irrational to make absolute conclusions because conclusions should be probable at best and probability does not equate to certainty were important nature of science convictions that would serve individuals in their everyday life, especially in the face of a world full of scientific claims.[167] While the Gilded Age scholars did not use the term nature of science, they clearly had in mind to teach various aspects of the nature of science as a part of a scientific education, and in the case of making education more functional, learning about the

[165] "Extracts."
[166] "University Studies."
[167] Faraday, "Education of the Judgment."

nature of science was yet another way to teach students how to use the though processes of science in their everyday lives.

Certain moral qualities were also claimed as functional outcomes of a science education. While John Tyndall used the term "moral qualities," he really meant a set of favorable character traits.[168] He asserted that patience, receptivity to nature, self-renunciation, love of truth, and the ability to part with biases and prejudices were personal qualities that specifically the inductive reasoning involved in physics could teach. He also wrote that prudence, foresight, sagacity, and self-checking were things that could be taught via a study of science, and Michael Faraday claimed patience and humility as positive outcomes of science teaching.[169] Augustus DeMorgan, a Gilded Age mathematician, added perseverance to this list as a positive moral quality science could teach.[170] Prudence and overcoming bad habits were declared as the natural outcomes of good reasoning (which would be taught by studying science) by James Paget, a prominent Gilded Age physician.[171] Finally, William Ballantyne Hodgson, a Gilded Age Scottish economist, claimed the lofty practical lessons of industriousness, independence, economy and frugality, and the necessity of forethought, judgment, and diligence as outcomes of a scientific education.[172] As with the nature of science, instilling these positive character traits in students was a favorable outcome of a scientific education. By promoting these various personal characteristics, education would be more functional because these were character traits that would serve in one's life outside of school, helping to prepare students to be productive citizens.

In summary, the argument as seen in *CDML* was that teaching science in the schools would help make education more functional for the students and do much more as well. While

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[168] "Study of Physics," 72.
[169] Tyndall, "Study of Physics;" and Faraday, "Education of the Judgment."
[170] "Intellectual Attainment."
[171] "Study of Physiology."
[172] "Study of Economic Science."

the classics could teach some thinking skills such as memory and precision of language, the idea was put forward across a variety of authors within *CDML* that science could train the mind (the status quo purpose of education) just as well, train the mind more broadly than the classics, and provide some utilitarian skills to the students as well. Over and above these traits, science would train the mind with process skills such as computation and logic, give methodical habits of thought such as deductive and inductive reasoning, confer various desirable character traits such as perseverance and foresight, and impart a mindset that embraced facets of the nature of science such as detecting a fallacy in logic and parting with one's biases.

Lastly, the struggle to provide a functional education to students, where the outcome would be to prepare them to live in a scientific world, use scientific habits of thought in their everyday lives, and use scientific process skills in their lives and jobs was a battle against a deeply seated conviction held by many, particularly classicists, that a functional education was low and sordid, that subjects that trained the mind could not, by their nature, confer useful knowledge, and that subjects that gave useful knowledge could not possibly train the mind at the same time. This is possibly why, even while arguing for a functional education, the scientists in *CDML* never lost sight of the fact that the traditional purpose of education was to train the mind. Science *could* train the mind, surely, but it could do so much more than that, providing practical educational outcomes that could far outstrip those of a classical education.

Functional Education as seen in Other Literature

The Purpose of Education

The Committee of Ten, writing their seminal *Report* near the end of the Gilded Age, stated what seems to have become, by then, the general purpose of education. They wrote that the main function of secondary schools was to prepare for the duties of life.[173] A classical curriculum advocate, Joshua Jones, writing at the beginning of the Gilded Age, had said that training the intellect was the main purpose of education, regardless of which studies were included in the curriculum.[174] Making education functional, the argument that will be explored in this section, and the rationale for making it so, evolved as a school of thought from the beginning to the end of the Gilded Age. The assumed function of education at the beginning of the time period was to train the intellect and the function of education at the end of the time period was to prepare students for life. It is my claim that the discourse on science education was a vital and critical reason for this shift in thinking about education.

It is easy to lose track of what the debate was really about. The debate was not about whether education should train the mind versus increase one's stock of knowledge versus prepare students for the various professions. As stated earlier, the purpose of education agreed upon by everyone, scientists included, was to increase mental discipline. The argument for a functional education was that education should train the mind in some functional way, giving students the thinking skills they could use in their lives – in other words, to prepare them for life. Increasing one's knowledge of scientific facts was only a very small part of this debate, but the case that science could both train the intellect and give positive knowledge at the same time was not an arguing point to be dismissed.

As noted above, scientists often pointed out that the two goals of education, mental discipline and imparting useful knowledge and skills, could not, in fact, be separated. Charles Halsey, who was actually a classicist, in a sentiment similar to Francis Wayland and Frederick Barnard in *CDML*, told his readers that it impeached the wisdom of our Maker to suppose that

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[173] National Educational Association [NEA], *Committee of Ten.*
[174] "Classical Study."

practical knowledge and mental discipline could be separated.[175] Herbert Spencer, foregoing remarks about God, instead placed the combination of gaining information and mental gymnastics on the "beautiful economy of Nature."[176] Assuming that the two could be separated would be contrary to nature's plan. The naturally following conclusion was that school subjects should be able to satisfy both goals of education. Halsey put the dual purpose of education most succinctly when we wrote that "The object of school education is to discipline the mind by acquiring useful knowledge."[177] Ideal subjects for a new, functional education would come under both heads, developing the powers of mind as well as being of interest, importance, and giving access to vital knowledge.

As already noted by the scholars in *CDML*, science was a subject that fit this bill quite nicely. In point of fact, science, in its role as both an educator of the mind and as a source of useful knowledge, was decidedly better than the classics. Thomas Henry Huxley claimed that science's form of mental discipline was better than all other subjects because of its special form of logic and its method of testing the validity of inquiry. Furthermore, as a source of useful knowledge, science gave information that could not be obtained otherwise.[178] Herbert Spencer also agreed that science was a superior subject than the classical languages for multiple educational purposes. For memory, science cultivated a better kind of memory than languages because languages cultivated mere memory while science cultivated memory along with understanding. For reasoning, science dealt with rational relations while language dealt only with non-rational (and thus less desirable) relations. For discipline, science cultivated judgment along with discipline, something languages could not do. Finally, for morals, an education via

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[175] Halsey, "Value of Studies."
[176] Spencer, *Education*, 79.
[177] "Value of Studies," 105.
[178] *Science and Education.*

languages gave an undue respect for authority while science did not.[179] Further evidence that a scientific education was superior to a classical education is found in an article from the *Atlanta Constitution* from 1870 claiming that science was superior to other subjects at disciplining the intellect because it had more vigor in reasoning, required more earnestness of effort, and had more severity in its search after truth.[180] Of course, classicists were ready with a response to these kinds of assertions. Language, particularly the classical languages, was better adapted to mental discipline because it was the chief instrument of our intelligence and was the tool that made thought visible and clear.[181] It may seem from discourse like this that the scientists were critical of the value of the classical curriculum, but that would be a hasty conclusion. As will be further explored below, there was an appreciable debate between classicists and scientists, but most scientists were not overly negative about the classics. Instead, the scientists' arguments simply showed how science could achieve the same and more goals as the classics, wishing only to include science in the curriculum rather than completely remove the classics.

John Stuart Mill, one of the most influential thinkers of the nineteenth century, also had something to say about the dual purpose of education and the role science could play. In his renowned inaugural address to the University of St. Andrews in 1867, Mill stated that the purpose of education was to train the intellect, furthermore stating that science could do this. Mill wrote that science was more important as a training and disciplining subject than as a stock of positive knowledge. He said that facts were the material of knowledge, but they could be gained at any time and anywhere, rather it was important in education to train the mind to

[179] Spencer, *Education*.
[180] "Claims of Scientific Study."
[181] Porter, "American College."

acquire facts and judge what they prove.[182] So, science could do both things, train the mind and give useful information, but the training of the mind was the more useful of the two.

It is interesting to note that Edward Livingston Youmans, in an 1867 letter to Herbert Spencer, took a rather dim view of John Stuart Mill's speech. He wrote:

> Mr. Mill has unwittingly done the most atrocious thing for the cause of real improvement in this country that any living man could have done. The whole theological world are in ecstacies [*sic*] over his performance at St. Andrew's [*sic*] as an unanswerable argument for the way things are. All he says for science goes for less than nothing – is never referred to, and all his unqualified claims for the classics are borne on the wings of the newspapers to the remotest part of the land … Mill's name is so potent that the opposite party has us at an enormous disadvantage.[183]

Youmans' reaction may have been a bit overdramatic, since it was written only five months after Mill's speech, and Mill *did* give some compelling reasons for teaching science in his speech. Mill said that scientific instruction was of "indispensable necessity" of a liberal education, that it was a subject that could train and discipline the mind, and that physical science exemplified the most perfect types of the "art of thinking."[184] In fact, in a personal letter from Mill to Spencer, Mill wrote that he did not think his argument in favor of the classics was too strong since there was a growing reaction in the opposite extreme.[185] Youmans wrote later in his letter to Spencer, "Somehow and by somebody that argument must be answered."[186] Scientists did, in fact, answer Mill and other classicists, fighting for an education that would be functional, using science to

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[182] Mill, "Inaugural Address."
[183] Youmans, as cited in Fiske, *Edward Livingston Youmans*, 236.
[184] Mill, "Inaugural Address," 233, 234.
[185] Mill, "To Herbert Spencer."
[186] Youmans, as cited in Fiske, *Edward Livingston Youmans*, 237.

train the intellect at the same time as impart useful knowledge. In fact, it would seem that *CDML* itself was a rather worthy answer to Mill's address.

George DeBoer, in his twentieth century history of science education, made an insightful remark about the discourse on the dual purpose of education during the Gilded Age. He wrote, "Science study provided knowledge of useful facts and the relationship among those facts, and it strengthened the intellect by offering an effective way of thinking about the natural world. Both of these were important to educators, but it was the strengthening of the intellect that was the more important function of science teaching."[187] It may be instructive to look back at some of the scholars cited above to see the verity of DeBoer's statement. It is probably reasonable to assume that the order of terms (i.e., mental discipline and *then* useful knowledge) can give insight into the author's underlying assumptions about the purpose of education, meaning that those who used the term mental discipline (or a variation of the term) first had the underlying assumption that this was the more important, or primary purpose of education. Looking back through the preceding section, one finds that the majority of scholars cited here used the term mental discipline first. (Those citations that were paraphrased rather than directly quoted were intentionally paraphrased using the original order of terms.) It seems, at least from this very small sample, that mental discipline was the primary aim of education, even when a more functional education was being called for.

Backlash Against Functional Education

A functional education, most broadly defined, was one that would discipline the mind via useful knowledge, the ultimate purpose of which was to prepare students for life outside of school. What exactly, though, did it mean to prepare students for life? And why was there such opposition to the idea?

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[187] *History of Ideas*, 7.

Benjamin Franklin, while admittedly outside the study period, was well known for his ideas on education, and one turn-of-the-century biographer noted that every word of his educational ideals "rings with altruistic utilitarianism."[188] Under Franklin's utilitarian education, the curriculum would be broad and functional, preparing students for the various professions. The notion of preparing students for their future professions was a rather consequential sticking point for many involved in the discourse. Today we have clear distinctions between vocational education and academic education, where vocational or technical education prepares learners for jobs that require manual activities related to a specific trade and academic education refers to the traditional secondary school curriculum. The discourse during the Gilded Age was sometimes unclear about the difference between vocational and academic education. Some scholars, particularly classicists, were mistaken about (or made no distinction of) the difference between educating students to prepare them for life (i.e., giving them the thinking skills and knowledge necessary for life) and preparing students for specific trades.

Hugh Legare, a Gilded Age classicist, gave a good indication of the mis-interpretation of a functional education that would prepare students for life when he wrote, "Our youth are to be trained up as if they were all destined to be druggist and apothecaries, or navigators and mechanists."[189] Joshua Jones, another classicist, also seems to have been under the misapprehension that useful education meant an education that had a direct bearing upon one's future business or calling. He felt that a functional education was confining education to training for professions or business.[190] Daniel Quinn, a Gilded Age member of the Department of Education, exemplified the misunderstanding that utility in education implied vocational training. He condemned those who wished for a functional education, writing that they "consider

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[188] Cloyd, *Benjamin Franklin,* 4.
[189] Legare, "Classical Study," 90.
[190] Jones, "Classical Study."

education as nothing more than a preparation for a career at some remunerative handicraft."[191] Even a man advocating for science in the curriculum used the term functional education in a vocational way; Daniel Coit Gilman, a Gilded Age educator, while praising the calls for teaching of science in the schools, made the statement that functional education was "immediately connected with the material advancement and civilization of mankind."[192] Another person advocating for the teaching of science in the schools did something quite similar, writing that science at one time afforded mental training and practical preparation for business.[193] This statement was written in the *New York Times*, which had a daily circulation of approximately 60,000 in 1875.[194] It may have been articles like this, particularly as this was in a widely read daily newspaper rather than discourse intended for intellectuals, where functional education was seen as akin to vocational education, that gave classicists and other anti-science advocates the wrong impression about what scientists meant when they talked about utilitarian goals of education.

Richard Hofstadter, in his mid-twentieth century critique of anti-intellectualism in America, gives some understanding of the somewhat common misconception that functional and utilitarian in education meant preparation for the professions. He wrote that business criteria dominated culture in the nineteenth century, and that this led to a number of realities – schooling was not to cultivate the mind but to make personal advancement possible, school should engage students with the practical tasks of life, and intellectual and cultural pursuits were seen as unworldly, unmasculine, and impractical.[195] While Hofstadter may be prone to hostility towards all he perceives as anti-intellectual, he may have a valid point here, as the dominance of business

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[191] Quinn, "Higher Education," 21.
[192] Gilman, "National Schools of Science," 501.
[193] "Science and the Classics."
[194] "The Exposure of a Fraud."
[195] *Anti-Intellectualism.*

in society may have been one factor causing the recurrent misinterpretation of what a functional education meant. If business interests were socially dominant during the Gilded Age, then it would be easy for people to interpret the desire to make education more utilitarian as having to do with business interests and thus vocationalism. Whether or not business was partly responsible for the misconception that a utilitarian education implied vocational training, this misconception oftentimes interfered with the discourse.

The scientists, for their part, understood the difference between a functional education that prepared students for life by teaching them how to think and giving them useful knowledge and a functional education that prepared students for their various professions – the scholars discussed here meant the former of these two when talking about functional education. For example, one Gilded Age scholar defined a functional education as that which increases one's capacity to analyze and comprehend new ideas.[196] While this may not have been a wholly satisfactory definition of what was meant by a functional education, it at least implied that functionality was preparation for the duties of life, not preparation for a manual trade.

There was quite a fair amount of hostility in the discourse concerning functional outcomes of education. Edward Livingston Youmans gave some indication of this in his introduction to *CDML*. He wrote:

> The adherents of the traditional system reply that all this is but the unreasoning clamor of a restless and innovating age, which wholly misconceives the true aim of a higher culture, and would reduce everything to the standard of a low and sordid utility. They maintain that knowledge is to be acquired not on account of its capability of useful application, but

[196] "The New Education."

> for its own intrinsic interest; that the purpose of a liberal education is not to prepare for a vocation or profession, but to train the intellectual faculties.[197]

Youmans' point was rather insightful and can be seen in much of the classicist discourse. Joseph Payne, a classicist, called the discourse on useful knowledge "meaningless clamour," rightfully insisting that what may be undeniably useful for some people may not be useful at all to others.[198] Some scholars, like Burke Aaron Hinsdale, a Gilded Age pioneer in education, felt that a functional education would be one that developed the whole man rather than serving the mere utilitarian needs of life. Hinsdale rejected the narrow definitions of a functional education that were "furnished by the money-winning sciences."[199] This seems to state a clear hostility to the scientists in their quest for making education more functional. Joshua Jones, a classicist, called the idea of usefulness in education "narrow and false," assuming that usefulness in education meant preparation for the vocations. He claimed that enlarging and sharpening the mental powers, developing accuracy of reading, developing sound and correct judgment, expressing thought clearly and powerfully, elevating the moral nature, and the attainment of truth *were* useful educational outcomes, but that these did not count for anything under the narrow and false definition of functional education.[200] This, of course, was wholly not true, as evidenced by the discussion above – scientists advocating for a functional education did mean the very same things Jones meant. This, however, seems to have been lost on Jones, and his hostility toward those advocating for a functional education is sharply pointed. He uses the term "vulgar utilitarianism" when describing utility in education.[201]

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197 "Mental Discipline in Education," 2-3.
198 Payne, "Classics and Science," 165.
199 *Schools and Studies,* 191.
200 "Classical Study."
201 Jones, "Classical Study," 54.

Other examples of hostility to the idea of a functional education abound in the Gilded Age classicist discourse. Hugh Legare, for example, criticized those who called for utility in education, writing that they had a “sheer abhorrence of the luxuries and prodigality of learning.”[202] There was even criticism of the state itself, which violated the rights of children when it undertook to prescribe their future careers. The assumption here was that utility in education implied that the school was involved in the “bread and butter interests of later life.”[203] Joseph Payne, yet another classicist, felt that those who wanted utility in education saw man solely “as a profession” rather than man as a citizen.[204] Apparently some classicists were afraid of the inhumanizing influence of science. The classics, as the study of man and mankind, as the foundation for mankind’s greatest literature, as the mirror into the soul, and as *the* way to character development, were humanizing studies; science, which could not make any of the same claims, was not only inhumanizing but also reeked of inhumanity. Furthermore, by supplanting classical study with utilitarian science, students would not acquire general culture. According to Thomas Hughes, a Gilded Age social reformer and Christian Socialist, one can never pick back up lost culture and a liberal way of thinking once out of school.[205] By imparting culture rather than utility, the whole man is educated, and he can pick up whatever knowledge he needs outside of school. By forgoing culture for function, men are irrevocably lost. It may be that the classicists were hostile to science education simply as a self-preservation tactic, arguing against any point put forth by scientists in order to maintain their hold as the leaders of education. With that said, making educational outcomes more utilitarian in nature may have been a valid sore point for classicists; because the scientists’ argument did not really address moral and character

[202] Legare, “Classical Study,” 89.
[203] Hinsdale, *Schools and Studies,* 179.
[204] Payne, “Classics and Science,” 173.
[205] Hughes, “Scientific Education.”

development, it is easy to see how the classicists, whose curriculum could boast moral and character development, would get so worked up about an education that they perceived as leaving moral and character development by the wayside.

Two modern day historians, Richard Hofstadter and Caroline Winterer, had something more recently to say about the perceived vulgar utilitarianism of a functional education. Hofstadter blamed Gilded Age businessmen for the culture of utilitarianism, writing that they held some sort of power over the "only one defensible way of life, the American way," where the "sum and substance of life lies in the business of practical improvement."[206] Here, the utilitarianism of a functional education is seen as a sort of demise of higher culture in America's Gilded Age. Winterer's interpretation is somewhat similar. According to her, part of the classicists' social critique of the Gilded Age was an assertion that the utilitarianism and materialism rampant in society were the product of the non-classically-educated majority.[207] If Winterer's analysis of the time is correct, the classicists of the Gilded Age argued against a functional education not only to save their own studies, but to save the world from the rampant utilitarianism and materialism that eventuated from an uneducated majority.

Winterer's argument is actually quite useful to look at. She wrote:

> How could late-nineteenth-century classicists compete with claims that utilitarian science was the intellectual and moral compass of higher education? Although a number of classicists continued to insist on the utility of classics – they disciplined the mind and promoted the acquisition of foreign languages, English grammar, and medical and legal terminology – such claims appeared increasingly desperate and even ridiculous next to the more obvious and remunerative social utility of engines and bridges. A far more

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[206] *Anti-Intellectualism*, 239.
[207] *Culture of Classicism.*

> successful strategy was to abdicate utility altogether and embrace its opposite: uselessness, construed in its modern sense as having no claim at all to explicit vocationalism, science, or economics.[208]

As has been seen throughout this discussion, the classicists did, indeed, claim the acquisition of mental discipline as the act of greatest significance of their curriculum. Furthermore, the classicists also argued for an education that would provide useful outcomes (under their definition of useful) such as educating the morals, cultivating the tastes, and forming the character. Did they, as Winterer claims, also adopt uselessness as an anti-science argument?

The answer here seems to be that yes, classicists did use the argument of uselessness at times. In essence there was something noble about the economic unprofitability of a classical education. For example, Joshua Jones argued that since the classical languages originated from such ancient antiquity, they had no connection with the political, religious, and social controversies of modern times, thus keeping students safe from vocational and other modern societal educational outcomes.[209] Joseph Payne made a similar argument, writing that education should decidedly *not* attempt to "force the individual man to keep up with the intellectual march of the human race."[210] In fact, the classics were so gloriously non-utilitarian that they helped students to know nothing of, and thus be unencumbered by, modern day issues and current knowledge. Hugh Legare wrote that a classical education should raise students "as far as possible above those selfish and sensual propensities, and those groveling pursuits, and that mental blindness and coarseness and apathy, which degrade the savage and the boor to a condition but a little higher than that of the brutes that perish." In fact, according to Legare, the common

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[208] Ibid., 110.
[209] Jones, "Classical Study."
[210] "Classics and Science," 163.

American person aimed at doing nothing more than “to draw existence, propagate, and rot.”[211] Legare’s words are a bit harsh (and certainly overdramatic and sweepingly general), but others made the same sentiment without the abusive language. Jones, for example, felt that the inutility of the classics, where not even the “smallest iota” of knowledge gained would be used in the transactions of business, and which was “profitless as regards its direct use” was a perfectly logical justification for keeping a classical curriculum.[212] As Caroline Winterer rightly maintains, the classicists did, in fact, “abdicate utility altogether and embrace its opposite: uselessness.”[213] It would be interesting to know if classicists espoused the uselessness argument because they truly felt that education should have nothing to do with the politics and society of the day or if they took up the banner of uselessness simply as retaliation against the utilitarian argument made by scientists.

Science and Technology

The somewhat common confusion among scholars that functional education implied vocational education may have been further compounded by the somewhat common misconception about the difference between science and technology. It may be instructive to understand what is today meant by the two terms, adding applied science to the discussion. To understand the nature of applied science, we first start with basic science. Basic science is primarily the investigation of natural phenomena, with the end result of discovering enduring principles. Applied science, simply, is the application of this scientific knowledge to solve practical problems. Technology uses scientific (or mathematic, or engineering, or linguistic) knowledge to create tools, machines, and crafts to control our environment.

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[211] “Classical Study,” 91.
[212] “Classical Study, 55.
[213] *Culture of Classicism*, 110.

The nuances of the characteristics of basic science, applied science, and technology may have been lost on many of the Gilded Age intellectuals, and perhaps some of the scientists themselves. John Wesley Powell, a Gilded Age geologist, gave a definition of technology from that day and time. He called technology "the science of industries," and industry "an activity whose purpose is welfare or livelihood."[214] Today, our definition may be more like the saying emblazoned on the rotunda of the Museum of Science and Industry in Chicago, "Science discerns the laws of nature…industry applies them to the needs of man." For his part, Jacob Bigelow gave a somewhat spirited perspective about technology in the Gilded Age, saying:

> It has happened in regard to technology that in the present century and almost under our own eyes, it has advanced with greater strides than any other agent of civilization, and has done more than any science to enlarge the boundaries of profitable knowledge, to extend the dominion of mankind over nature, to economize and utilize both labor and time, and thus to add indefinitely to the effective and available length of human existence. And next to the influence of Christianity on our moral nature, it has had a leading sway in promoting the progress and happiness of our race.[215]

Bigelow, himself a physician and scientist, may have conferred considerable weight to technology in his address but frankly did not give a wholly satisfactory definition for the term, perhaps showing that even those enamored with science and technology were not entirely clear about the distinctions between the two.

An article in *Scientific American* may give a more straightforward answer to what Gilded Age people understood to be technology - the immediate use derived from a scientific

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[214] "Technology," 319.
[215] Bigelow, *Limits of Education*, 3-4.

discovery.[216] A *New York Times* article indicated that commercial success (stemming from scientific research) would define technology, and elsewhere the mere "practical application of science to relieve man from his distresses" was sufficient a definition.[217] But, in actuality, it seems that little distinction was made (at least in the written word) between science, applied science, and technology. In an article entitled "Notes on Recent Progress in Applied Science" from 1879, things such as the telephone, the electric light, and magneto-electric machines are mentioned as examples of applied science.[218] Today we would probably classify these things as technology. The same article discussed the newly understood ultimate constitution of matter (i.e., atoms and molecules), where individual molecules act less as a mass than as discrete elastic balls flying about like on a billiard table. This, surely, is not applied science but rather true science, where the enduring properties of nature are discovered or understood.

Other examples of the probable ignorance of the difference between science, applied science, and technology abound in the literature of the Gilded Age. For example, Josiah Cooke, an prominent chemist of the Gilded Age, attributed the following conveniences and comforts of daily life to physical science: the railroad, steamship, electric telegraph, photography, gas lights, coal-tar colours, chlorine bleaching, and anesthesia. To Cooke, these were the "material fruits" of science.[219] Maybe Cooke preferred to use the term material fruits of science rather than technology or applied science as a way to steer clear of his own misunderstandings. Ernst Mach, a renowned Austrian physicist and philosopher of the time period, also had inaccurate designations in his discourse, calling knowledge of soil fertility and solar heat "science" rather

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[216] "What is the Use?"
[217] "Chemistry that Pays;" and Newman, *Beneficence of Science*, 3.
[218] Morton, "Applied Science."
[219] *Scientific Culture*, 6.

than applied science.[220] Jacob Bigelow, in a similar vein, called steamships and batteries "science," refraining from using the term technology; and Simon Newcomb, a Gilded Age astronomer and mathematician, following suit on inaccurate classifications, called the dynamo and the electric car examples of applied science, although these are really examples of technology.[221] It is interesting indeed that the above examples of misuse of the terms science and applied science all came from scientists. Craig James Hazen, a twentieth century historian, claims that the scientists themselves are to blame for this confusion, writing that the public had no care for abstract science that had no practical use, so scientists stressed the practical value of their work.[222] Hazen's insight seems reasonable, where the scientists may have been writing at the level of the general public, using the terms that they perhaps thought the public would better understand. Many of the above examples did come from popular news outlets such as newspapers and lecture series rather than from scholarly discourse.

Although there may have been an incomplete understanding of the differences between science, applied science, and technology, it was not necessarily important to the argument for including science in the curriculum to understand or acknowledge the distinction between these. The important point to make was that science (but more correctly, technology) had pervaded ordinary life. Gilded Age scientists and classicists alike were ready with a laundry list of scientific technologies that were now a part of daily life. Sewage disinfecting, photography, sugar refining, soap boiling, glass and porcelain making, brewing, the telegraph, and the kitchen range were some technologies mentioned by Gilded Age scholars.[223] Steam power, photography, telegraphy, the steam engine, smelting, fuel economy, gunpowder, sugar refining, bleaching,

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220 *Popular Scientific Lectures,* 352.
221 Bigelow, *Limits of Education*, 23; and Newcomb, "Science During the Victorian Era."
222 *Village Enlightenment*.
223 Spencer, *Education*.

dyeing, and agricultural knowledge were some technologies named by historians of the Gilded Age.[224] Ernst Mach claimed that science "permeates all our affairs, our whole life; everywhere its ideas are decisive."[225] Josiah Cooke specifically pointed to the elementary principles and facts of chemistry as being "intimately associated with the experience of everyday life."[226] Thomas Henry Huxley agreed that science was intimately associated with everyday life. He tried to take some of the mystery out of science, writing that we all practice scientific processes in "the humblest and meanest affairs of life."[227] Science was merely the organizing and training of common sense, and this brings the discussion to the true meaning of the scientists' definition of preparation for life – science was a thinking process to be used in everyday life.

Thinking Like a Scientist

As detailed above, the scientists referred to in this chapter argued that science could fulfill the dual educational goals of teaching students how to think and providing useful knowledge. Here is where we can begin to understand what the intellectuals meant by teaching students how to think – the scientists meant teaching students how to think like a scientist, using the methods and processes of scientific thinking in their everyday lives.

Even William Gardner Hale, a renowned classicist, agreed that a scientific habit of thought was a necessity that the spirit of the age demanded. He defined a scientific habit of mind as the ability to observe, generalize, and prove, and wrote that this habit of mind was a tool that everyone, no matter what his or her field of work, must possess.[228] One specific field of work, namely government service, was cited as a profession that would greatly benefit from a scientific habit of mind. In what seems like a criticism of public officials, Sir David Brewster, a Gilded

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[224] Ibid.; and DeBoer, *History of Ideas.*
[225] *Popular Scientific Lectures*, 352.
[226] *Scientific Culture*, 6.
[227] *Science and Education,* 45.
[228] *Classical Study.*

Age scientist, wrote that a scientific mind could help us understand how the interests of the state are mismanaged or neglected and how public wealth is squandered.[229] While it is not entirely clear how exactly a scientific education could help cure the ills of government incompetence, Brewster exemplifies the Gilded Age mindset (at least amongst scientists) that a scientific habit of mind could go a long way in one's everyday life.

In this line of reasoning, science was a method and a way of thinking, not a set of facts. According to Thomas Chamberlin, a Gilded Age scientist and president of the University of Wisconsin, scientific inquiry involves certain fundamental habits of thought that can become fixed in one's intellectual nature, thus positively influencing their subsequent actions.[230] What, though, where these fundamental habits of thought? In general, it could mean simply strengthening the reason, judgment, and imagination. It could mean to simply thinking more carefully and closely about both scientific and non-scientific things. It could mean training and strengthening one's common sense. A scientific habit of mind would be one that would look beyond the immediate and forecast distant consequences; understand facts (be they scientific or not), their sequence, and their significance; put an end to superstition; and understand and thus enjoy nature. The ideal scientific mind had a hatred of falsity and the ability to guard against the disturbing influence of feelings and prejudices.[231] These were some examples put forth by Gilded Age scholars as scientific ways of thinking, but there was also much more included in the discourse about what it meant to be able to think like a scientist.

Aspects of the nature of science were included in the notion of thinking like a scientist. According to the Committee of Ten, a scientific habit of thought meant the practice of

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[229] Brewster, "Opening Address."
[230] Chamberlin, *Address*.
[231] Ibid.; Fiske, *Edward Livingston Youmans*; Huxley, *Science and Education*; Mach, *Popular Scientific Lectures*; and Pearson, *Grammar of Science.*

investigating carefully, making clear and truthful statements, and having a taste for original investigation.[232] In similar scientific language, Josiah Cooke felt that a scientific habit of mind meant the ability to follow out a chain of probable evidence with care and caution, eliminate accidental circumstances, use experiment to supply the missing links, and draw a final conclusion.[233] A scientific habit of mind that incorporated aspects of the nature of science would be a mind that had reverence for truth and knowledge, being be less inclined to dogmatism and less inclined to undue respect for and deference to authority. Herbert Spencer fleshed out this line of reasoning a bit more, writing that scientific truths are not accepted upon authority alone, that all are at liberty to test the veracity of scientific truths, and that there is a constant appeal to individual reason when scientific discoveries or truths are made.[234] The notion of having reverence for truth was to some extent a point being made against the classical curriculum, where axioms were commonplace and deference to authority was routine. More than a reverence for truth though, a scientific education could teach students to keep their minds unbiased, to make decisions in their everyday lives without the burden of personal bias, personal feelings, and the idiosyncrasies of the individual.[235] As will be explored further in the next chapter, there seems to have been a great need during the Gilded Age for the lay public to be able to use some of these mental characteristics, particularly the ability to make decisions without personal bias. Not only was this the duty of every citizen in a democracy, to make decisions and vote on issues in an impartial way, but it was also a necessary frame of mind in a world where scientific hoaxery was rampant. In fact, understanding something of the nature of science (e.g., how to make scientific

[232] NEA, *Committee of Ten*.
[233] Cooke, *Scientific Culture.*
[234] Spencer, *Education*; and Wilson, “Natural Science in Schools.”
[235] Cooke, *Scientific Culture*; and Pearson, *Grammar of Science*.

conclusions, the weight of scientific evidence, certainty in science, etc.) would be a major asset in the war against scientific hoaxery.

While Thomas Henry Huxley felt that a scientific habit of mind would allow people to face scientific problems in society, James Wilson, a Gilded Age theologian and scientist, felt that simply being able to recognize that something *was* a scientific problem and being able to know which kind of scientific specialist [e.g., a chemist versus a geologist] to refer to was a sufficiently scientific habit of mind.[236] Knowing something was a scientific issue and being able to deal with such issues were both important societal reasons for teaching students to be able to think like a scientists.

Nowhere was the ability to think like a scientist more crucial than in dealing with new scientific theories and the change in worldview that often accompanied new theories. The Gilded Age was a time of an almost cataclysmic change in people's worldview, and the ability to keep up with changes in though was a positive social reason for advocating teaching students to think like scientists. Charles Darwin's *On the Origin of Species* was published in 1859 and Herbert Spencer's term "survival of the fittest" was published in his *Principles of Biology* in 1864. The theory of evolution (fleshed out by both Darwin and Spencer, both of whom were villainized by anti-evolutionists) pervaded thought and philosophy in the Gilded Age. A few sweepingly general statements can show the reaction of contemporaries. Edward Livingston Youmans wrote that evolution "is the new dispensation of scientific thought, cropping out everywhere antiquating old views, affording new explanations, reorganizing knowledge, and guiding the researches of scientific men in every field of investigation."[237] Karl Pearson, a Gilded Age contributor to mathematical statistics, wrote:

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[236] Huxley, *Science and Education*; and Wilson, "Natural Science in Schools."
[237] Fiske, *Edward Livingston Youmans*, 559.

> Within the past forty years so revolutionary a change has taken place in our appreciation of the essential facts in the growth of human society, that it has become necessary not only to rewrite history, but to profoundly modify our theory of life and gradually, but none the less certainly, to adapt our conduct to the novel theory. The insight which the investigations of Darwin, seconded by the suggestive but far less permanent work of Spencer, have given us into the development of both individual and social life, has compelled us to remodel out historical ideas and is slowly widening and consolidating our moral standards.[238]

Further confirming the altered worldview of people living in the Gilded Age due to the theory of evolution, Lawrence Cremin, in his educational history, wrote that Spencer offered Americans an all-encompassing philosophy that had a marked effect on an entire generation of American thinkers.[239] Being able to think like a scientist meant not only being able to keep up with new scientific discoveries, but also to process new theories and be open to change in one's worldview. This was especially important in the Gilded Age when new scientific understandings were numerous, like the pioneering work done in the fields of electricity and magnetism and the resulting technologies such as incandescent lighting.

The nineteenth century was also notable for mankind's enlargement of thought with respect to time, thanks to scientific geology.[240] Ideas like uniformitarianism, stratigraphic succession, and the resulting reckoning of the incredibly ancient age of the earth (during the Gilded Age the age of the Earth was put at somewhere in the tens to hundreds of millions of years, although today we believe the Earth to be approximately 4.5 billion years old), were debated but generally accepted during the latter part of the nineteenth century. This greatly

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[238] Pearson, *Grammar of Science*, 1.
[239] *Metropolitan Experience.*
[240] Fiske, *Century of Science*.

expanded people's conception of time, once again forcing a change in worldview. Finally, the notion of the interconnectedness of science became apparent to scientists at the end of the Gilded Age. John Fiske asserted that people at the end of the century began to realize that the subject-matter of the various sciences were not independent and detached groups of facts but rather they were all intimately linked with one another.[241] While these things were not necessarily an overt aspect of the discourse explored in this chapter, it can be inferred that scientists wanted to instill a scientific habit of thought into students in order to better have them receive evolution and the new scientific thought that was permeating society. More than this though, the sometimes cataclysmic change in worldview that accompanied such new theories would be an easier transition if one already possessed a scientific habit of thought.

The point made in *CDML*, that various process skills were also included in the notion of thinking like a scientist, was substantiated elsewhere in Gilded Age discourse. Arguably one of the most frequently cited process skills that a scientific education could furnish was the skill of observation.[242] Charles Eliot saw the value of teaching science over the classics because the classics were solely learned out of books. Science would teach students to use their powers of observation and judgement, whereas the learning of languages from books did no such thing.[243] Even the esteemed Committee of Ten, or rather the Committee on Natural History, the subcommittee that filed a report to the Committee of Ten, stated that teaching students observation skills was the purpose of studying science.[244] Observational skills were a functional outcome of a scientific education because people used these types of skills in their everyday lives.

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[241] *Century of Science.*
[242] Dryer, "Science in Secondary Schools;" Fiske, *Edward Livingston Youmans*; Hale, *Classical Study*; and Mach, *Popular Scientific Lectures*.
[243] *Educational Reform.*
[244] NEA, *Committee of Ten*.

The ability to classify things was another process skill that was often cited, although not all scholars clearly defined what they mean by the term classification. Edward Livingston Youmans used simply the term classification, while Ernst Mach called it the ability to distinguish between cases, and Karl Pearson went a step further, writing that classification of facts and subsequent formation of judgment based on the facts was what was important.[245] Other process skills that would be positive functional outcomes of a scientific education found in the Gilded Age literature include the ability to make clear and truthful statements, the ability to express oneself, the ability to make generalizations, the ability to ascend from actual facts to abstract ideas, and the ability to create proof of a fact.[246] Some of these skills may strike the modern day reader as more closely related to the nature of science than to process skills, but since neither term was used by Gilded Age scholars, and since the examples above were all mentioned with an outlook more closely related to process skills, they are classified as such here. In one final example of discourse about process skills, a report on the 1878 World's Fair in Paris indicated that America was "behind Europe in the education of the sense, of the power of observation, and manipulation."[247] Comparison with the educational systems of other developed nations, particularly at a World's Fair, should probably not be overlooked as a motivating factor in the push for a more functional education. While none of the intellectuals, neither scientist nor classicist, explicitly made this a part of their argument, it may have been an underlying tension that spurred on change, particularly as World's Fairs were held somewhat frequently during the Gilded Age and were, to some extent, the way information travelled.

Like their peers in *CDML,* other Gilded Age scientists felt that a functional education could also help instill certain moral characteristics that were part of an ideal scientist. Beneficial

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245 Fiske*, Edward Livingston Youmans*; Mach*, Popular Scientific Lectures;* and Pearson*, Grammar of Science*.
246 Ibid.; Whewell, "Educational History of Science;" and Hale, *Classical Study*.
247 Chamberlain, "Universal Exposition," 344.

character traits that a scientific education could help instill included ingenuity, perseverance, and sincerity.[248] Francis Walker, president of the Massachusetts Institute of Technology [MIT] during the Gilded Age, wrote that scientific study breeds intellectual honesty, a moral characteristic that counteracts the use of false arguments, the use of clever but unsound reasoning, and self-delusion.[249] In fact, a scientific education could counteract a number of negative moral characteristics: carelessness, credulity, superstition, and falsehood.[250] A love for truth (and a counteraction to falsehood) was an important moral characteristic that scientists claimed science could give. According to some scientists, a scientific education would habituate the mind to demand absolute truth because science deals with certainties and raises the mind above the insecurities of imperfect knowledge.[251] This statement would seem to counteract what we understand today about the nature of science, particularly that scientific knowledge is not perfect, but it is important to understand what the Gilded Age scholars said without correcting them for possibly misunderstanding the nature of science.

In all, the basic argument as laid out in *CDML*, that teaching science in the schools would help make education more functional for the students, that science could train the mind and provide some more functional outcomes like process skills, methodical habits of thought, and positive character traits, was echoed by many other scientists in the Gilded Age. There was considerable discourse between scientists and classicists about the value of a functional education, and this public discourse may have helped the scientists to more clearly set out what they meant when they said that educational outcomes should be more functional. When the argument is looked at as a whole, however, it seems that, in the end, much of the discourse

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[248] Dryer, “Science in Secondary Schools.”
[249] “Scientific and Technical Schools.”
[250] Dryer, “Science in Secondary Schools.”
[251] Fiske, *Edward Livingston Youmans*.

focused around training the mind, which was the status quo purpose of education. While the scientists claimed that science could both train the mind and confer other positive outcomes, most of these other outcomes boil down to various aspects of mental discipline. If this is the case, the argument made by the classicists that a functional education was sordid seems baseless, since the ultimate outcome of a functional education was still mental discipline.

Functional Education as Relates to Scientific Literacy

As the previous section of this chapter has shown, the discourse seen in *CDML* was both a product of the times, where more utilitarian outcomes of education were needed, and was being echoed in the larger intellectual arena, with particularly intense discourse between scientists and classicists. As with the previous chapter, the discourse in *CDML* is being treated as a representative sample of thought during the Gilded Age. As also noted in the previous chapter, I paid special attention to points that may have laid some foundations for our modern day notion of scientific literacy as I analyzed the discourse in *CDML*. By analyzing the discourse through a modern day lens of scientific literacy, I can gain greater insight into the discourse, a deeper analysis of it, and a way to organize my thinking about it. For an in-depth review of the current discourse on scientific literacy, please refer to Appendix A.

Within the discourse in *CDML*, fifteen of the twenty-eight scholars found in the book concerned themselves with some aspect of making the curriculum more functional or utilitarian. While not all aspects of their arguments relate to our modern day understanding of scientific literacy, it became clear that certain points made by the Gilded Age scholars are consonant with our current notion of scientific literacy and thus serve as a foundation for the present day discourse. As with the previous chapter, this discussion will be organized according to the nuances found in the modern day literature on scientific literacy.

Social Responsibility

In the modern day literature on scientific literacy this nuance includes issues that relate to responsible and active citizenship such as being able to understand scientific issues one reads in the media, being able to discuss these issues knowledgeably, and, moreover, being able to make informed democratic decisions about scientific issues.[252] In other words, scientific literacy involves using decision-making skills for scientific issues.[253] Scientific issues in today's public agenda could include things like nuclear power, acid rain, genetic engineering, food and agriculture, drugs, cancer, recycling, sanitation, and pollution, just to name a few. Here, an understanding of the concepts and principles of science is less important that decision-making skills and the ability to participate in a democracy where scientific issues arise.

Scientific literacy for social responsibility is an underlying tenet of some of the arguments in this chapter, where science is called upon to make education more functional. The argument to teach science to prepare students to live in an increasingly scientific world is an example of scientific literacy for social responsibility. As the opening quote of this chapter indicates, science had altered society greatly in the closing decades of the nineteenth century. Science had permeated everyday life, being intimately associated with the experiences of ordinary life, and technology had advanced with great strides, extending man's dominion over nature, adding to the length of human life and man's daily comforts. The increasingly scientific nature of life meant, as Edward Livingston Youmans said, that science was destined to exert increasing influence over public questions.[254] The scientifically literate citizen would be able to make informed decisions about scientific issues in the public agenda and understand discussion

[252] DeBoer, "Scientific Literacy;" Ewing et al., "Improving Student Attitudes;" Glynn and Muth, "Reading and Writing;" Koelsche, "Scientific Literacy;" and Oliver et al., "The Concept of Scientific Literacy."
[253] Hurd, "Scientific Literacy;" Kolstoe, "Consensus Projects;" Lee and Roth, "Science and the 'Good Citizen';" Meehan, "Nuclear Safety;" Miller, "Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.
[254] "Science and Social Reform."

of scientific issues in the popular media. As James Wilson said, the simple act of being able to recognize something as a scientific problem and being able to know which experts to turn to for answers was a reason to teach science.[255] Again, this recognition of a problem as scientific was the mark of a scientifically literate citizen.

Being able to think like a scientist in one's everyday life is another hallmark of the scientifically literate individual that can be found in the modern day literature.[256] This was also an important issue that can be found in the Gilded Age literature. The argument between classicists who felt that a functional education implied vocation training and scientists who meant that a functional education implied preparing for life by teaching students how to think may have been reduced if this underlying assumption about scientific literacy were overt. The classicists misunderstood what a functional education would do, thinking that students would be taught to be steamship operators, druggists, apothecaries, mechanists, or (God forbid) scientists. The scientists, for their part, understood that science education was a way to prepare students for life, not for their future careers. Students would be taught to think like scientists so that they could use scientific thought processes in their daily lives, no matter where their post-school lives took them. A scientifically literate student could use inductive and deductive reasoning, the ability to form lucid and precise ideas, and abstraction and generalization skills in their everyday lives. Thinking processes like these would prepare students for life, giving them mental tools to use, not manual tools for future professions. One wonders if the classicists had understood this, or if the scientists had explicitly set out this notion of scientific literacy, if the classicists' hostility to a functional education would have be lessened, since teaching students to think like a

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255 "Natural Science in Schools."
256 AAAS, *SFAA*, 186; Kolstoe, "Consensus Projects;" McGinn and Roth, "Preparing Students;" and Shamos, *The Myth of Scientific Literacy*.

scientists was, as has been shown above, not terribly different from teaching students how to think like a classicist.

Some of the "uselessness" arguments made by classicists pointed out that the classics had no connection with the political and social controversies of modern times, allowing students to know nothing of modern day issues and thus not be burdened by them. The fact that classicists felt the need to resort to this kind of argument may lead us in the other direction, namely that science would allow students to know something of modern day societal issues. This of course was what the scientists wanted – they wanted students to know something about the modern world and how to live in an increasingly scientific world. Scientific literacy for social responsibility would certainly have been an unstated assumption of this argument because the fundamental premise of the argument was that social responsibility, or knowing about societal issues, was a desirable thing.

Interaction of Science and Society

The interface of science and society is another common thread of discourse in the modern day literature on scientific literacy. Morris Shamos calls this "science-based societal issues."[257] The fundamental assumption here is that science is socially situated, and that being able to recognize and respond to the interaction of science and society is the primary motivating factor in promoting scientific literacy. The standard modern-day argument given for promoting scientific literacy here is for students to be aware of, and be able to respond to, societal impacts of science.[258]

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[257] Shamos, *The Myth of Scientific Literacy*, 77.
[258] Bybee, "Achieving Scientific Literacy;" Culliton, "Dismal State;" Evans, "Scientific Literacy;" Ewing et al., "Improving Student Attitudes;" Hofstein and Yager, "Societal Issues;" Miller, "Scientific Literacy;" and Mitman, Mergendoller, Marchman, and Packer, "Components of Scientific Literacy."

Being aware of and able to respond to societal impacts of science is a major tenet of modern day scholars who advocate for scientific literacy as relates to the interaction of science and society. Gilded Age discourse on the topic was not so dissimilar to this. The laundry list of scientific and technological advances made in the Gilded Age was often given as a reason why science should be taught. Things like the railroad, steamship, photography, coal bleaching, batteries, the dynamo, electric cars, telegraphy, smelting, and sewage disinfecting were societal impacts of science and technology, and Gilded Age scholars saw the need to teach science in order for students to be able to deal with these sorts of things in their lives. While Gilded Age scholars may not have used modern-day phrasing about how things like electric lighting and sewage disinfection were socially situated impacts of science, their basic message was not much different from that of today's scholars who use these words because the Gilded Age scholars, like their modern-day counterparts, saw the need for people to be able to manage the products of science and technology in their everyday lives. The Gilded Age scholars appreciated that things like the telephone and the incandescent light bulb were socially situated impacts of science and that it was necessary to create scientifically literate individuals who would be able to deal with these things in their lives.

The Gilded Age scholars examined in this chapter also thought beyond the concrete products of science and technology. The societal impacts of something like the theory of evolution or the theory of the age of the Earth may not have been as tangible as the societal impacts of something like the dynamo, but that does not mean they did not exist. By recognizing that these major shifts in mindset were significant, the Gilded Age scientists realized that people needed to learn science in order to be able to cope with new scientific discoveries, particularly those that precipitated a change in one's world view. Modern day scholars of scientific literacy have also acknowledged the importance of students processing new scientific ideas and possibly having to change their frame of mind as a result.[259] The scientifically literate individual, both now and in the Gilded Age, is able to process new scientific discoveries and, if necessary, incorporate them into their own worldview.

Organization of Knowledge

Modern day scholars of scientific literacy only occasionally cite the organization of knowledge as a facet of scientific literacy, and it is never the sole criteria for advocating for scientific literacy. Scholars define the organization of knowledge as knowledge and understanding of the basic facts and principles of science as well as the basic vocabulary of science.[260] The organization of knowledge is also defined as encompassing the thinking skills of science such as analyzing, interpreting, classifying, predicting, controlling variables, using both deductive and inductive reasoning, and becoming independent and logical thinkers who are good at problem-solving.[261]

Arguably the most important skill of science in the modern day literature on scientific literacy would be the ability to think like a scientist, and this includes such things as analyzing, interpreting, classifying, predicting, controlling variables, and using inductive and deductive reasoning. Gilded Age literature struck a similar tone. They used phrases such as strengthen the reason, judgment, and imagination; look beyond the immediate and forecast distant consequences; follow out a chain of probable evidence; eliminate accidental circumstances; and draw conclusions. Their terms may have been different, but the message was similar – science should be taught in order for students to learn to use the thinking skills of science.

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[259] Atwater, "Science Literacy;" Lee, "Science Knowledge;" and Roth, "Scientific Literacy."
[260] AAAS, *SFAA*; *Benchmarks*; Koelsche, "Scientific Literacy;" and NRC, *Standards*.
[261] Fensham, "Science for All;" Glynn and Muth, "Reading and Writing;" Koelsche, "Scientific Literacy;" Palincsar et al., "Pursuing Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.

One further aspect of the modern day definition of the organization of knowledge is acquiring scientific habits of mind like honesty, open-mindedness, curiosity, skepticism, and the ability to identify one's assumptions.[262] The Gilded Age literature, once again, struck a similar tone. Gilded Age scholars recognized that science could instill certain moral characteristics in learners such as ingenuity, perseverance, sincerity, patience, humility, foresight, industriousness, and a love for truth. Science could also uproot certain negative moral characteristics such as self-delusion, carelessness, superstition, sophistry, and casuistry. A scientifically literate individual, both today and in the Gilded Age, would ideally possess the positive moral characteristics of a scientist.

Conclusion

To review, the main argument explored in this chapter revolved around making educational outcomes more functional and making education more utilitarian. Gilded Age scientists wanted to prepare students for life outside of school, and this brought up discussions about the purpose of education, where scientists wanted to supplement the status quo purpose of education of mental discipline with more functional outcomes like useful skills and knowledge. The push to include more practical outcomes of education was an uphill battle for the scientists as they worked against hostility to the notion of making education utilitarian. In particular, many classicists were under the misapprehension that a utilitarian education was the same thing as vocational education, where students would merely be trained up for specific future jobs. This misapprehension led to hostility on the part of the classicists, who ultimately adopted the argument that the classics were superior because they were not useful. For their part the scientists argued that science could confer various skills, foremost among them being the ability to think like a scientist in one's everyday life. Outcomes such as classification skills, understanding facts

[262] AAAS, *SFAA*; *Benchmarks*; Fensham, "Science for All;" and NRC, *Standards*.

and their significance, having a reverence for truth, being unbiased, and recognizing scientific problems were merely some of the examples of utilitarian results a scientific education could achieve.

Preparing students for life outside of school was the underlying premise for advocating for a functional education. As noted in this chapter, science and technology were ubiquitous in life outside of school, as were situations where a scientific habit of thought would serve one well. One such situation was the common circumstance of being confronted with bold scientific claims and various forms of scientific hoaxery. It is to this that we now turn.

You hear at the present day, that some persons can place their fingers on a table, and then elevating their hands, the table will rise up and follow them; that the piece of furniture, though heavy, will ascend, and that their hands bear no weight, or are not drawn to the wood: you do not hear of this as a conjuring manoeuvre, to be shown for your amusement, but are expected seriously to believe it; and are told that it is an important fact, a great discovery amongst the truths of nature.

Faraday, "On the Education of the Judgement"

CHAPTER 4

SCIENTIFIC FRAUD

Introduction

This chapter will be presented in a manner similar to the previous two chapters, where the discourse in *CDML* is used as a foundation. This discourse will then be examined and analyzed utilizing other Gilded Age literature and various secondary sources from both the twentieth and twenty-first centuries. As such, in the first section of the chapter the arguments found in *CDML* will be laid out as they appear in that book, with discussion and elaboration being saved for the second section of the chapter. Finally, in the third section of the chapter the Gilded Age discourse will be examined through the lens of our modern day notions of scientific literacy.

In this chapter I consider those arguments relating to scientific fraud, where the concern of the Gilded Age scholars was in combating the widespread occurrence of scientific hoaxes and fraud. The works of the scholars considered here show that they were concerned about the prevalence of scientific fraud perpetrated on the public, and their argument was that a scientific education could help combat this, mostly by instilling an understanding of the nature of science in students. In the second half of the chapter I briefly examine and explain many of the common hoaxes of the Gilded Age. Included is a short debunking of some of the hoaxes, demonstrating some of the knowledge and thinking skills necessary to debunk scientific fraud. There is also a detailed look into the various aspects of the nature of science that the Gilded Age scientists felt would be an aid in disproving scientific fraud; this includes such things as how to detect poor science, asking for evidence, understanding how to weigh scientific evidence, make a scientific claim, and establish a scientific fact.

Scientific Fraud as Seen in *Culture Demanded by Modern Life*

There was an overwhelming concern by some of scholars in *CDML* about the all-too-common occurrence of scientific hoaxery in society. Michael Faraday took this issue the most seriously, with Edward Livingston Youmans and George Paget putting emphasis on this topic too. James Paget, William Carpenter, and Richard Owen adding to the discussion. The principal argument here was simply that science ought to be taught in order to combat scientific hoaxery and widespread quackeries. Included within this basic argument were various points about the nature of science and being able to think like a scientist. But the main point was simply that a scientific education could help deter or perhaps avoid scientific fraud. William Carpenter, Registrar of the University of London, summed up the main argument by writing that people believed scientific hoaxes for want of a scientific habit of mind, that it would be easier for people to recognize scientific fallacies if they had a scientific habit of mind, and that common misconceptions associated with scientific frauds would be laid to rest with some scientific learning in school.[263] There are more distinctions seen in the arguments made by other scholars, but Carpenter's points were the basic premise of all of the arguments that will be explored in this chapter.

Five of the scholars in *CDML*, William Carpenter, Michael Faraday, Richard Owen, George Paget, and Edward Livingston Youmans, referenced specific hoaxes and quackeries. There were multiple contexts under which scientific frauds were alluded to, but all of these authors addressed some aspect of the formal or informal education of the populace. Carpenter mentioned hoaxery in the context of teaching students what constitutes adequate proof for a scientific claim; Faraday wrote about the education of judgment, one aspect of which was being able to judge for oneself the veracity of scientific claims; Owen, a Gilded Age biologist and outspoken critic of the theory of evolution, attributed the success of scientific fraud to people's ignorance of natural history; George Paget was concerned that people believed absurd and impossible things for a lack of scientific understanding; and Youmans felt that if we understood human nature, we could likewise understand quackery. Specific quackeries referenced by these men include clairvoyance, the crystal globe, electro-biology, flying through the air, ecstasy, hallucinations, homeopathy, hysteria, mesmerism, necromancy, odylism, the pasilalinic sympathetic compass, perpetual motion, reverie, ring-swinging, somnambulism, spectral illusions, spiritualism, supernatural powers, table-lifting, table-rapping, table-speaking, and table-turning.[264] In the first section of each chapter I aim to lay out only the scholars' arguments as found in *CDML.* The analysis of their arguments will come in the second section of the chapter where I explore other literature from the Gilded Age and secondary sources from the twentieth and twenty-first centuries. Because none of these scholars explained any of these

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[263] "Extracts."

[264] Carpenter, "Extracts;" Faraday, "Education of the Judgement;" Owen, "Extracts;" Paget, G., "Influence of Scientific Culture;" and Youmans, "Scientific Study of Human Nature."

hoaxes, these and other hoaxes will be described and explored further in the next section of this chapter. It is worthy of attention to note that the absence of any explanation of the various hoaxes mentioned in *CDML* may indicate that the hoaxes were so widespread and commonly known that there was no need to explain them to the readers. Similarly noteworthy is the point that the scholars in *CDML* did not make distinctions between scientific claims made and hoaxes perpetrated under false pretenses and those scientific claims that their perpetrators believed were genuine. In the Gilded Age, the terms *hoax, quackery, fraud,* and *folly* seemed to have been synonymous for all sorts of pseudo-science.

George Paget suggested that teaching science could help in the struggle against scientific hoaxery and "barefaced quackeries."[265] Michael Faraday's essay can give us some deeper insight into why this was the case. He wrote that hoaxes like table-turning (a method of consulting spirits where several persons sit around a table and wait for the table to move, rotate with considerable rapidity, or rise in the air) could be easily debunked with a little scientific knowledge – like Newton's third law (For every action, there is an equal and opposite reaction.), which would disallow for the unassisted raising of the table.[266] The implication here was that sometimes simply a basic understanding of the laws of nature would help in the struggle against scientific hoaxery.

Michael Faraday was undeniably the most outspoken and passionate of the scholars in *CDML* on the topic of scientific hoaxery. It would seem that Faraday had been called upon often in the past to debunk certain scientific hoaxes, and his lecture, "Observations on the Education of the Judgment," was somewhat of a tirade against those hoaxsters. In a clearly heated sentiment, Faraday wrote:

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[265] "Influence of Scientific Culture," 418.
[266] "Education of the Judgment."

> Where are the established truths and triumphs of ring-swingers, table-turners, table-speakers? What one result in the numerous divisions of science or its applications can be traced to their exertions? Where is the investigation completed, so that, as in gas-lighting, all may admit that the principles are established and a good end obtained, without the shadow of a doubt? … What has clairvoyance, or mesmerism, or table-rapping done in comparison with results like [electricity]? What have the snails at Paris told us from the snails at New York? What have any of these intelligences done in *aiding* such developments? Why did they not inform us of the possibility of photography; or, when that became known, why did they not favour us with some instructions for its improvement? …Why have they not added one metal to the fifty known to mankind, or one planet to the number daily increasing under the observant eye of the astronomer? Why have they not corrected one of the *mistakes* of the philosophers? … How is it that not one new power has been added to the means of investigation employed by the philosophers, or one valuable utilitarian application presented to society?[267]

Faraday's passion on this topic seems to have come from his own personal experiences. He wanted science to be taught in the schools so that people would not have to rely on men of science to be the judges of scientific hoaxes. Faraday, as a man of science, had better things to do with his time than debunk every hoax that came around. He wrote, referring to the clearly common occurrence of being asked to debunk hoaxes:

> When men, more or less marked by their advance, are led by circumstances to give an opinion adverse to any popular notion, or to the assertions of any sanguine inventor, nothing is more usual than the attempt to neutralize the force of such an opinion by reference to the mistakes which like educated men have made; and their occasional

[267] Ibid., 219-221.

> misjudgments and erroneous conclusions are quoted, as if they were less competent than others to give an opinion, being even disabled from judging like matters to those which are included in their pursuits.[268]

Here one can see that the double-edged sword of being a famous scientist upset Faraday – he was repeatedly called upon to make judgments about scientific claims, but when his judgment was contrary to popular liking (i.e., when he judged a claim to be fraud or a hoax), his ability as a scientist was challenged. It seems, at least from Faraday's two essays in *CDML*, that this was an overwhelming reason why he advocated for teaching science in the schools. He wanted people to be able to judge for *themselves* the veracity of scientific claims, and a scientific habit of mind, particularly an ability to form correct judgements, would move the average person forward toward achieving his goal.

The ability to detect poor science, where not enough evidence had been collected or presented, or an outright hoax, where evidence was purposely withheld, was a fundamental aspect of the argument here. For all of the scholars in *CDML* who discussed scientific fraud, an understanding of the nature of science was the most significant part of a scientific education that could combat scientific fraud. Gilded Age scholars did not use the term *nature of science*, but our modern day understanding of the topic shows that the Gilded Age scholars did, in fact, have nature of science in mind as they discussed this issue. The concept of the nature of science is recognizable in the language of science discussed in these essays. For instance the authors discuss testing, verifying, making hypotheses, drawing conclusions based on an analysis of data, and stating the basis on which one might be willing to give up their ideas.

An elementary understanding of what was, and what was not, scientifically possible contained an aspect of the nature of science that could help individuals to combat scientific

[268] Ibid., 218.

fraud. George Paget made this point when he wrote that people were unsure of what was and was not science. He wrote that some scientific inventions seemed so unbelievable that people had no way of distinguishing between real science like the electric telegraph and false science like table-turning. Moreover, Paget wrote, if real science seemed so unbelievable, then on what basis should the average person make decisions about what to believe? “Startled with scientific wonders beyond their comprehension, they gape at and swallow indiscriminately every new thing that is presented to them under the outward guise of science.”[269] In other words, you believe everything when you don’t know how to tell the difference between real science and pseudo-science. The hope was that a scientific education would steer the public in the right direction of belief, putting their trust in real science and their disdain on pseudo-science.

Understanding scientific evidence or what it takes to make a scientific conclusion was another aspect of education in the nature of science that the scholars felt could combat hoaxery and quackery. James Paget felt that if people understood scientific proof they would be more discerning about scientific claims.[270] Today in the study of the nature of science, the term scientific proof is considered archaic, but at that time it was not. James Paget’s brother, George Paget, agreed that the lack of scientific training amongst most people meant that they did not know what it took to establish scientific fact. Combined, these authors felt that the important things a scientific education could impart in terms of countering scientific fraud were an ability to tell true and false scientific statements, an understanding of the weight of a body of evidence, and an understanding of the kind and amount of evidence necessary to establish a scientific truth.[271] In terms of the value of a body of evidence, Michael Faraday felt that it was important people understand that conclusions should be proportionate to the evidence and that conclusions

[269] “Influence of Scientific Culture,” 419.
[270] “Study of Physiology.”
[271] “Influence of Scientific Culture.”

should never be more than highly probable. He also thought it imperative that people understand that a scientific hypothesis is not the same thing as a scientific fact.[272] Edward Livingston Youmans also saw the importance of this aspect of the nature of science. He thought it important that students learn to weigh probable evidence, think about contingencies, and understand that scientific conclusions are often based on imperfect knowledge.[273] These ways of thinking would help people to detect scientific fallacies, particularly by questioning the evidence and conclusions scientific hoaxers put forth. A classical education did not have provisions for this sort of questioning.

One of the problems with a classical education, according to Edward Livingston Youmans, was that Latin and Greek began with the unquestioning acceptance of data and axioms and promoted the passive acceptance of authority.[274] A passive acceptance of authority was precisely the problem with the acceptance of scientific hoaxery as truth – people believed everything peddled under the name of science, passively accepting even the most impossible of feats like tables flying through the air unassisted. Michael Faraday was also incensed by the unquestioning acceptance of data, riled by those who blindly and obstinately hold on to principles even when they are proved erroneous.[275] By teaching students to question evidence and assertions made by all sorts of people (both hoaxsters and others), students would be gaining a valuable mindset that they could use in many areas of their lives, not just in regards to scientific hoaxery.

The recognition of uncertainty in scientific method was another aspect of the nature of science discussed by the scholars in *CDML*. Michael Faraday wanted people to understand that

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[272] "Education of the Judgement."
[273] "Mental Discipline in Education."
[274] Ibid.
[275] "Education of the Judgement."

probability is not the same thing as certainty, writing that absolutism was both irrational and improper.[276] James Paget was of a like mind, writing that there is uncertainty in knowledge, and that students should learn that accepted knowledge is not necessarily true.[277] Likewise, Edward Livingston Youmans was of the opinion that by learning to deal with uncertainties, students would be protected against the "numerous fallacies and impostures which are current in society," including "the charlataneries of medical treatment" and "so-called 'spiritual manifestations'".[278] Understanding that there is uncertainty in knowledge, both scientific and otherwise, was another important mindset, like the questioning of data and assertions, that students could use in their everyday lives.

Another argument put forth in *CDML* was that an understanding of some of the characteristics of the nature of science might help alleviate the too-common problem of being unable to reason cause and effect. If, for example, people understood that the cause of a table raising three feet off the ground was the result of scientific forces that followed the laws of nature, they might be more discerning about where they placed their belief. In cases like this, where people did not relate cause and effect, it was an error in judgment. Education to encourage this type of rational judgement was Michael Faraday's main arguing point, and he began his argument by pointing out that errors in making judgements did not stem from our senses, for they perform their duty quite satisfactorily; rather, the interpretation of sense data and the ensuing judgments based on those interpretations were faulty.[279] So, seeing a table raise was not the problem, the problem was reasoning why and how it had occurred. This notion leads to another aspect of the nature of science discussed in *CDML*, namely preventing self-deception.

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[276] Ibid.
[277] "Study of Physiology."
[278] "Mental Discipline in Education," 36.
[279] "Education of the Judgement."

A properly trained mind would, according to Michael Faraday, be "open to correction, upon good grounds, in all things, even in those it is best acquainted with."[280] In fact, Faraday took up this banner against self-deception single-handedly in *CDML*, being a most vociferous opponent of wishful thinking. He wrote about his observation that all people, scientists and lay-people alike, seek evidence that favors their own desires and disregard evidence that opposes them. In point of fact, Faraday admitted to wanting certain outcomes to his own experiments. But for him a sense of appropriate scientific integrity meant that he would not succumb to the creation of false data or even the use of unrigorous data. He felt it was important, especially in order to combat scientific hoaxery, that students should educate their minds in order to resist their desires and inclinations when seeking proof, and that they should learn to recognize their own ignorance. People were apt to draw conclusions based on their ignorance, prepossessions, passions, and accidents, and Faraday felt that possession of an educated mind, which included being conscious of one's faulty judgment, would go a long way in combating scientific hoaxery and quackery.

In summary, the argument presented in *CDML* was rather simple – students should be taught science so that they would be mentally prepared to deal with scientific frauds that were rampant in society. A mind trained in science, and especially what we today call the nature of science, would not be fooled by false science. And this training would include knowing some of the laws of science, such as Newton's Third Law, which would spare people from believing scientific impossibility of tables flying through the air. With that said, an understanding of various aspects of the nature of science was more important here than an understanding of certain laws of nature when it came to combating scientific hoaxery. Specifically, understanding what was and was not scientifically possible, understanding scientific proof and evidence and

[280] Ibid., 201.

what it takes to make a scientific claim, dealing with uncertainties in knowledge, understanding cause and effect, and resisting one's own desires for certain outcomes were a number of aspects of the nature of science that could counteract the widespread belief in scientific fallacies.

Scientific Fraud as seen in Other Literature

There was quite a bit of outrage on the part of Gilded Age scientists when it came to scientific hoaxes. As noted in the preceding section, Michael Faraday was incensed at the boldness of the assertion of the hoaxsters, the unwillingness of advocates to investigate, and the credulity of onlookers.[281] William Carpenter, who took it upon himself to debunk many Gilded Ager hoaxes in his book *Mesmerism, Spiritualism, Etc.*, called spirit-related hoaxes an "epidemic delusion," where the upholders of the hoaxes failed to afford scientific proof of the existence of any new forces of nature.[282] William Robinson, another popular Gilded Age debunker, riled against hoaxsters who, "no sooner are they caught and exposed while employing one system that they immediately set their wits to work and evolve an entirely different idea." He called spiritual mediums charlatans who victimized those seeking knowledge.[283] While there was clear hostility towards scientific hoaxery by the Gilded Age scholars examined here, their irritation was constructive because it made them address the issue and find ways to counteract the influence of hoaxery in society.

In his book *Science and Education*, Thomas Henry Huxley asked the all-important question, "Why is it that quackery rides rampant over the land?"[284] He would have likely agreed with Matthew Goodman, a twenty-first century historian, who called the nineteenth century a

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[281] "Education of the Judgement."
[282] *Mesmerism, Spiritualism.*
[283] Robinson, *Spirit Slate Writing,* iv.
[284] *Science and Education*, 61.

time of superstition and fanaticism.[285] George Paget, however, had an interesting, although not wholly adequate answer to Huxley's question. In his opinion, the increasing payment given to real scientific discovery and invention (presumably he was referring to the monetary benefit of technology based on one's scientific discovery, where scientists were not being paid to discover electricity but rather for the harnessing and use of electrical currents) enhanced quackery and imposters because hoaxsters wanted to get in on the cash.[286] Paget may have been correct, but that did not sufficiently answer the question of why hoaxery was so rampant – even if hoaxsters got into the business by the boatloads, their pursuits would only be lucrative with an accommodating public.

In a similar mindset as Thomas Henry Huxley, J. H. Brown, a Gilded Age debunker of hoaxes, wanted to know why, "in this age of scientific research, the absurd follies of spiritualism should find an increase of supporters?"[287] From his twenty-first century perspective, Matthew Goodman wrote that the assumption that the advantages of wealth, intelligence, and high station would prevent people from falling victim to impostures is a wrong assumption, that nineteenth century history is rife with counterexamples.[288] The simple answer to the question of rampancy of scientific hoaxery was a lack of early scientific training among the public. Before we further examine how Gilded Age scholars felt science education could combat hoaxery, it may be instructive to first understand what exactly these hoaxes and impostures that so readily took hold of Gilded Age society were.

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285 *Sun and Moon*.
286 "Influence of Scientific Culture."
287 *Spectropia,* 7.
288 *Sun and Moon*.

A Brief Explanation of the Common Hoaxes

It is important to point out that Gilded Age scholars involved in this discussion were not talking about prestidigitation, where magic tricks are performed for an audience as pure entertainment. While many hoaxsters did put on spectacular performances, and while many hoaxes were quite entertaining, the presumption was that either new scientific wonders were being shown or the hoaxster intentionally meant to deceive and mislead. (The differences between prestidigitation and hoaxery may be subtle, but it is important nonetheless.) While the term hoax has been used in this research, it is also important to point out that, firstly, all of the occurrences presented here are set forth only in the context of their Gilded Age setting, with the understanding that today we may have a better understanding of some of these phenomena, and that secondly, as already noted, some of the presenters of these phenomena did not feel that they were hoaxes. With that said, the Gilded Age scholars themselves were partial to the term hoax, and those scholars examined here seem to have felt that all of the phenomena to be examined were, in fact, hoaxes. As such, the term hoax will be used here. What follows will be a brief overview of all of the hoaxes specifically mentioned by the scholars in *CDML* as well as a number of other well-known hoaxes not specifically mentioned. The hoaxes will be presented alphabetically for simplicity's sake, and each will be discussed only briefly and as relates to the later nineteenth century. For further insight into these and other hoaxes, the interested reader can refer to the footnotes in the upcoming section. Books such as J. H. Brown's *Spectropia*; William Carpenter's *Mesmerism, Spiritualism, Etc.*; Georges Didi-Huberman's *The Invention of Hysteria*; William Robinson's *Spirit Slate Writing*; and Alison Winter's *Mesmerized* all give detailed insight into various hoaxes.

Clairvoyance was the power of discerning objects not present to the senses, or the ability to perceive a contemporary physical event beyond the range of ordinary perception, or the ability to know events that have occurred in the past or will occur in the future. As opposed to telepathy, where information is passed from the mind of one individual to another, clairvoyants gained their information directly from an external physical source such as a crystal ball.[289]

Crystal gazing, or crystallomancy, was the ability to gaze at a crystal ball for purposes of clairvoyance. Seers, or those who gazed into crystal balls, would divine information predicting past or future events, discern objects or people not present, or help people to make a decision about current problems. In essence, the crystal ball was the external physical source used by some clairvoyants.

A *divining rod* was a forked twig, in the shape of a "Y," that would be used to find underground water springs or metallic veins. The user would hold the rod, one hand on each branch of the Y, walk over the ground with the stem facing forward, and wait until the diving rod began to shake. When this occurred, the spring or metallic vein would be located under the diving rod.[290]

The *educated fly* was a fly that could, essentially, read. An easel would be set up on a stage with a grid on it, with twenty-eight spaces, one for each letter of the alphabet, one for zero, and one left blank. The fly would begin at the blank space, an audience member would call out a certain letter (such as the letter "G"), and the fly would move over the correct letter ("G" in this case), and then move back to the blank space.[291] This would occur over and over again, although it is unclear if it was for the purpose of spelling out a word or message, or simply to have the audience continue to call out random letters.

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[289] Para psychological Association, http://parapsych.org/glossary_a_d.html, retrieved August 18, 2009.
[290] Carpenter, *Mesmerism*.
[291] Robinson, *Spirit Slate Writing.*

Ecstasy was an altered state of consciousness characterized by a lack of awareness of one's surroundings, the inability to communicate with other people, and (possibly) the communication with the divine. As opposed to hypnosis, the subject of ecstasy did not lose consciousness or will, rather they had a heightened awareness of the spiritual.[292] Ecstasy was sometimes one of the stages of hysteria.[293] Ecstasy is one of the hoaxes of the Gilded Age that it is important to understand within the time frame of the nineteenth century, for today we often mean something quite different, something more secular and pedestrian by the term.

Electro-biology was something akin to both sleepwalking and hypnotism. The electro-biologist could, simply by holding a little disk of zinc or copper near the subject, paralyze their muscles, control their voluntary motions, deprive them of the power of speech and memory, and induce obedience to any command. This was often done on stage to a wiling member of the audience.[294] As opposed to sleepwalking, the subject here was not asleep. There seems to have been little difference to hypnosis, other than that the electro-biologist used a metal disk to induce the desire effects.

An *hallucination* was a perception in the absence of a stimulus. Hallucinations could be visual, auditory, or olfactory. There is little in the Gilded Age literature to lead to the conclusion that it was different from what we believe today about hallucinations. Most likely hallucinations were felt to be scientific hoaxes because even scientists had not yet understood what causes hallucinations and the physiognomy behind them.

Homeopathy was a form of alternative medicine that treated patients with heavily diluted solutions. The underlying tenet was that diseases have spiritual as well as physical causes, and

[292] "Ecstasy," http://en.wikipedia.org/wiki/Ecstasy_(emotion), retrieved August 18, 2009.
[293] Didi-Huberman, *Invention of Hysteria*.
[294] Carpenter, *Mesmerism*; and "Stage Hypnosis," http://en.wikipedia.org/wiki/Stage_hypnosis, retrieved August 18, 2009.

that a disease could be cured by causing effects similar to the symptoms presented by the disease.[295] There was, in the Gilded Age, no real supporting scientific evidence in favor of the effectiveness of homeopathy.

Hysteria is another scientific hoax that it is important to understand within the confines of the later nineteenth century, as the term means something closer to panic or alarm today. The term was rediscovered in the Gilded Age by Jean-Martin Charcot, a doctor at Salpetriere, a madhouse for women in Paris. There was a laundry list of possible manifestations of hysteria including spasms, the mimicking of an epileptic fit, fits of ecstasy, plastic poses, and a predilection to hypnosis. It was felt that hysteria was a women's ailment, caused by the displacement of the uterus; the uterus was understood to be an animal spirit that could move within the torso, and an out-of-place uterus would cause hysteria.[296]

Mesmerism was, in the Gilded Age, something akin to hypnosis. At around the turn of the nineteenth century Franz Anton Mesmer claimed to have discovered a new force of nature, animal magnetism, that was the free flow of magnetic fluid through the body. Illness was caused by obstacles to this flow of animal magnetism, and Mesmer felt that illness could be cured by accelerating or aiding the efforts of nature. In effect, diseases could be cured by provoking the symptoms of the disease via magnetism. By the Gilded Age, mesmerism was more of a stage show, where the mesmerist would use their hand to make sweeping passes over the face of the subject, allowing the subject to sink into a mesmeric trance, where the senses of smell and touch disappeared, the awareness of surroundings disappeared, and a strange communion would develop between the mesmerist and the subject, with the subject being able to speak the

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[295] "Homeopathy," http://en.wikipedia.org/wiki/Homeopathy, retrieved August 18, 2009.
[296] Didi-Huberman, *Invention of Hysteria.*

mesmerist's thoughts, taste the food in his mouth, and move their limbs in echo of the mesmerist.[297]

Necromancy, in the context of the Gilded Age, seems to have been used as a catchall phrase for things like séances, spiritualism, and table-rapping. In definition, necromancy is a form of magic where the practitioner summons spirits.[298] While necromancy is today often connotated with black magic and summoning demon spirits, it is unclear if that connotation was applied during the Gilded Age. Certainly critics of spiritualism felt that the summoning of spirits was false science, but it does not seem from the literature of the time that dark magic and demonology were necessarily associated with parlor séances and table-turning.

Odylism was the theory of *od*, a hypothetical force that pervaded all nature. Baron von Reichenbach, the founder of the theory in the 1860s, said that he had discovered a new force distinct from all known forces and attractions. He called this force *odyle*, and it was present in all material substances to differing degrees. According to odylism, certain sensitive subjects were especially affected by magnets or crystals, and they would feel a pricking or shooting sensation if touched by one of these and could see flames coming out of a magnet or crystal.[299]

The *pasilalinic-sympathetic compass* (also called the *panasilinic telegraph*) was sometimes called the snail telegraph. It was "discovered" that two snails brought into mutual relation for a time would establish a sympathy, through a special type of fluid that forms an invisible thread, that would allow them to correspond movements no matter how far apart they eventually were. The pasilalinic compass was a contraption set up where one snail would walk

[297] Winter, *Mesmerized*.
[298] "Necromancy," http://en.wikipedia.org/wiki/Necromancy, retrieved August 18, 2009.
[299] Carpenter, *Mesmerism*.

over a dial with the letters of the alphabet on it, and another snail, on a different dial board, would walk over the same letters, spelling out a message.[300]

The *pendule explorateur* was an apparatus where a ring was suspended by a thread from the finger over a glass tumbler. Although it is not entirely clear what exactly the device was meant to do, it seems that the ring would strike the glass to tell the hour. A *magnetometer* was a similar device. It was a gallows-shaped frame mounted on a solid base, having a metallic ball hanging from the gallows. An operator would lightly touch the frame, and the magnetic ball would oscillate in some definite direction.[301] Common sense would lead one to infer that the base had some sort of alphabet on it so that the oscillations of the ring or metallic ball would spell out a message.

Perpetual motion is the notion that once set in motion a device can go on forever without additional mechanical inputs. Mechanically, it refers to a machine that can perpetually produce more energy than it consumes; also, it refers to a machine that can sustain motion indefinitely, not losing energy to friction and air resistance. Apparently the (attempted) invention of perpetual motion machines was popular during the Gilded Age.[302] The laws of physics are incomplete even today, thus we would presently not consider perpetual motion to be hoaxery, just unexplained circumstances. Nonetheless, perpetual motion was classified as hoaxery by Gilded Age scientists.

Séances were popular parlor diversions where a medium would call spirits. There were both light and dark séances, their names implying the lighting conditions of the séance. During a séance various things could happen; a spirit might appear, the table might lift and move about, or

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[300] Ibid., and "Pasilalinic-sympathetic compass," http://en.wikipedia.org/wiki/Pasilalinic-sympathetic_compass, retrieved August 18, 2009.
[301] Carpenter, *Mesmerism.*
[302] "Perpetual Motion," http://en.wikipedia.org/wiki/Perpetual_motion, retrieved August 18, 2009.

sound might be heard. Apparently there was a customary arsenal of musical instruments that would be present at a séance that included bells, tambourines, and guitars.[303]

Somnambulism, or sleepwalking, was a sleep disorder where the sufferer engaged in activities normally associated with wakefulness. Evidently Baron von Reichenbach developed his theory of odylism by studying sleepwalkers. The somnambulist was a conscious automaton, the mind in a state of activity but free from personal will power.[304] It would seem, from the Gilded Age literature, that somnambulism was a stage trick where an audience member would be put into a state of somnambulism during a stage performance.

Spectral illusions were, as the name implies, the appearances of ghosts. According to J. H. Brown, in the only Gilded Age discourse I have been able to uncover on the topic, spectral illusions were often cloaked figures, pointing fingers and arms in a certain direction, or else they were skeletal figures either cloaked or not.[305]

Spirit photography was a process whereby one would sit for a photograph, with the resulting photographic image showing both the sitter and the shadowy image of a spirit.[306] Apparently the photograph was meant to prove that a spirit was present in the room with the photographer and the sitter.

A *spiritoscope* was a table with a circular board attached to its side. The circular board was somewhat like a roulette wheel, having a space for each letter. The letter board was attached to wheels on two legs of the table, and a medium would sit at the table with their hands on large brass spheres. As spirits spoke to the medium, the table would tip until the letter board had

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[303] Robinson, *Spirit Slate Writing*.
[304] Carpenter, *Mesmerism*; and "Sleepwalking," http://en.wikipedia.org/wiki/Sleepwalking, retrieved August 18, 2009.
[305] *Spectropia.*
[306] Robinson, *Spirit Slate Writing*.

landed on the correct letter, and a message would be spelled out by consecutive tippings of the table.[307]

Spiritualism was a term for the belief that spirits of the dead could be contacted. Many prominent spiritualist mediums of the Gilded Age were women, and they travelled around the country performing séances and stage shows where the dead would be contacted. Some historians set the date of March 31, 1848 as the beginning of spiritualism. This was the date when the Fox sisters of New York made their first contact with the spirit in their house. The Fox sisters were the originators of table-rapping, to be described below.[308]

Slate writing was a way for mediums to contact spirits. Spirits would write messages on slate tiles, which the medium would then be able to read or reveal to audiences.[309]

Table-lifting (also called *table-turning*) was another way for dead spirits to contact the living. During a séance a number of people would sit around a table, each lightly touching the surface of the table with their hands or fingers. As the medium contacted the spirits, the table would lift off the ground and sometimes move across the room.[310]

Table-rapping was a way of contacting spirits where messages would be spelled out by raps on a table. The Fox sisters of New York began this phenomenon; they were able to place their hands on almost any hard surface and hear thuds or raps. At first the number or raps were a simple no (1 rap), yes (3 raps), and wait (2 raps) system; later the sisters worked out an alphabetical system for the spelling out of messages from the spirits.[311]

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[307] Hazen, *Village Enlightenment*.
[308] "Spiritualism," http://en.wikipedia.org/wiki/Spiritualism, retrieved August 19, 2009.
[309] Robinson, *Spirit Slate Writing*.
[310] Ibid.
[311] Carpenter, *Mesmerism*.

The Debunking of the Common Hoaxes

It was a favorite past-time for certain Gilded Age scholars and scientists to debunk hoaxes. Even P. T. Barnum, the famous nineteenth century showman, wrote *Humbugs of the World* as a dissection of cons and tricksters that included séance rappers, faith healers, diviners, and false prophets.[312] J. H. Brown, William Carpenter, and William Robinson were three Gilded Age scholars who took it upon themselves, often as a hobby, to debunk common hoaxes. Others, like Michael Faraday, had little time for such pursuits even though they were often called upon to do just that.

It is important to remember in the context of the Gilded Age discourse on science education that the mere debunking of various hoaxes was not enough – the heart of the matter was to teach students science so that they would be able to debunk any hoaxes themselves, understand what it takes to make a scientific claim, and discern between science and pseudo-science. Furthermore, some hoaxes were easy enough to debunk if one simply had the appropriate scientific knowledge.

What follows will be an analysis of some of the literature devoted to debunking scientific hoaxes; it is presented here for a multi-fold purpose – firstly to allow the modern day reader to more fully understand the hoaxes discussed above, secondly to show that often simple scientific knowledge could discredit a hoax, and thirdly to show that if specific scientific knowledge could not discredit a hoax, often a scientific habit of mind was sufficient for debunking. Again, the hoaxes will be presented in alphabetical order, and each hoax will be treated in only a cursory manner. Again, those interested in the details of Gilded Age hoaxes and their debunking would do well to read the books found in the footnotes to this section and those books found in the footnotes for the above section where the hoaxes were defined.

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[312] Goodman, *Sun and Moon*.

The *diving rod* was proved to be a hoax through physiological reasoning. It was found that one could not possibly hold the rod in the same position for more than fifteen minutes, that muscular tension would eventually point the rod by the simple pressure of the fingers, even if this muscular tension was unintentional and unconscious. Furthermore, tests with blindfolded practitioners showed uncertain, contradictory, and negative results.[313] In other words, the practitioner had some previously set idea about where to find water or minerals, and they would pretend to use the diving rod until they were standing on top of the previously set site.

The *educated fly* was truly a deception. There was a man (usually a man of small stature) sitting behind the lettered easel – he would sit on a platform so that the audience could not see his feet below the letter board. This man would use a strong magnet to move the fly to whichever letter was called out by the audience, and then he would move the fly back to the blank space.[314]

Hysteria was considered by many skeptics to be closer to theatre than to science. The hysterics willingly participated in hysterical demonstrations for audiences and often raised the stakes with their increasingly theatricalized bodies. Furthermore, Jean-Martin Charcot was able to induce hysterical episodes in his patients, on a stage before an audience.[315] These things would point to hysteria being a hoax. William Carpenter felt that hysterics and their doctors had the expectation of certain results, and that this alone was sufficient to evoke these results. Physiological science and medical science both had abundant and varied illustrations that proved this theory.[316] Carpenter's point, that the expectations of certain results is enough to provoke them, is essentially a corporeal example of a placebo.

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[313] Carpenter, *Mesmerism*.
[314] Robinson, *Slate Spirit Writing*.
[315] Did-Huberman, *Invention of Hysteria*.
[316] Carpenter, *Mesmerism*.

Mesmerism was explained by William Carpenter in much the same way as he explained hysteria. A knowledge of physiology and pathology, of both the body and the mind, gave knowledge about the physical excitability to the nervous system, about the possession of the mind by dominant emotions or ideas, and about self-deception. Furthermore, those who were able to be mesmerized surrendered themselves without due enquiry, and they had the predisposition to believe in occult agencies.[317] In essence, Carpenter was able to explain away mesmerism, hysteria, and hypnotism by the argument of power of suggestion.

Odylism's results, when put under scientific investigation, were found lacking. The responses of sensitive individuals were purely subjective, so there was no scientific way to prove that crystals and magnets had the force of od emanating from them. Because the responses were purely subjective and physiological, they could just as easily have come from internal or mental influences.[318] Odylism was not debunked in the way some of these other hoaxes were; rather, scientists concluded that the results could not be proven scientifically.

The *panasilinic-sympathetic compass* was debunked when one of the discoverers of the telepathic link between snails, Jacques Toussaint Benoit, tried to demonstrate his apparatus. Apparently Benoit set up the two snails in different rooms in the same house, and Benoit walked between the two rooms repeatedly during the demonstration, thus throwing doubt on the veracity of his results. When asked to repeat his experiment, Benoit refused.[319]

The *pendule explorateur* and the *magnetometer* were both debunked with the same line of reasoning. If the eyes of the practitioner or the person whose finger the ring was tied to were blindfolded, the results were not the same and the ring or metallic disk would not move like it

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[317] Ibid.
[318] Ibid.
[319] "Pasilalinic-sympathetic compass," http://en.wikipedia.org/wiki/Pasilalinic-sympathetic_compass, retrieved November 9, 2009.

should. Physiological knowledge showed that there were minute nervo-muscular movements in the hand of the practitioner that produced the movements of the ring or metallic disk.[320]

Dark séances were "so barefaced and bold it is hardly worth while to worry about them. What cannot be done in the dark?"[321] A simple debunking of a dark séance went as follows: the room was dark and the medium leaves the room; shortly after that a spirit enters the room; the debunking scientist touches the arm of the spirit with his hand, which is painted with blue ink. When the lights are turned back on, and the medium is once again sitting at the table, the scientist reveals what he did, and sure enough there is blue ink on the arm of the medium.[322]

J. H. Brown devoted an entire book to the debunking of *spectral illusions*. He first pointed out that all of the senses are subject to deception, and none more so than the eye. He went on to educate the reader about the structure of the eye and the nature of light in order to educate on how one's sight can be deceived.[323] The exact physiology of the eye and the nature of light are not necessary to elucidate here, the important thing is that Brown was able to debunk spectral illusions with simple physiological and physical science.

Spirit photography was easily debunked if one knew the science behind photography. If a long shutter speed were used, a shadowy image could be produced behind the sitter, as the sitter stayed still and a person in a cloak moved behind him across the frame while the shutter was open. Also, a microscope picture of a person in a cloak (i.e., a spirit) could be inserted into the camera alongside the lens so that the spirit would show up on the same frame as the sitter.

[320] Ibid.
[321] Robinson, *Spirit Slate Writing*, 106.
[322] Carpenter, *Mesmerism*.
[323] Brown, *Spectropia.*

Furthermore, a spirit could be printed on the negative beforehand and then the sitter's portrait would be printed over it, allowing both images to be present on the final photograph.[324]

Slate writing was debunked with knowledge of chemistry and knowledge of physiology. In terms of chemistry, invisible ink could be made that would appear through heat or other reagents. Some examples of known invisible inks included caustic potash, ammonium hydrochlorate, copper nitrate, copper perchloride, copper bromide, cobalt chloride, cobalt oxide, and a laundry list of others. The hoaxster would write a message on the slate beforehand and then reveal he message to his audience using heat or reagents. In terms of physiology, a medium could write on a slate under the table using his toes, while holding hands with the subject above the table. Because the subject's hands were being held, he was not free to examine underneath the table, making it a safe place for the medium to write on the slate.[325]

Table-lifting and *table-turning* were debunked with some ingenious thinking on the part of skeptics, many of whom participated in séance events over and over again until they had figured out the hoax. In some cases, two pins would be driven into the table, and the medium would wear a ring around each wrist, with a slot cut out for the pin. The medium would be able to lift a small table by carefully and secretly sliding the pins into the cuffs while their hands were laid on the table. A strong upward pressure of the hand would pull the pin out after a successful table-lifting, thus allowing the séance members to examine the table. In another instance, two threads would be run across the room, and two confederates of the medium would work the threads, lifting them up to catch under the table. It would seem that the thread would have to be almost transparent in order to fool the audience. In yet another instance, one or more confederates of the medium would sit around a large and heavy table with the other séance

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[324] Robinson, *Spirit Slate Writing*.
[325] Ibid.

members, hopefully as far apart from the medium as possible. They would all wear leather cuffs with a hook on the bottom; while gently placing their hands on the table, they would secretly secure the hook under the table while their wrists and the leather cuff would be above the table. By having multiple confederates, even a heavy table could be lifted.[326]

Table-rapping was debunked both by the Fox sisters themselves and by skeptics. As for the Fox sisters, they admitted to their friend, Mrs. Culver, who then gave testimony to the admission, that they made the rapping sounds by cracking their toes. They also admitted that if the medium watched the countenance and the gestures of the audience carefully enough, they almost invariably gave involuntary expression to their expected answers.[327] Although the Fox sisters began the table-rapping movement, the movement soon spread throughout the country and other mediums produced the same effects, although not always by cracking their toes. Other methods that were used to produce raps included pressing one's boot heel against the table leg, where the sound of leather against wood made a rapping sound; sliding one's fingers along a varnished table top; using an electro-magnet concealed under the table; displacing the tendons of the muscle; and snapping one's knee joints.[328]

While the preceding discussion has not presented evidence of the debunking of all of the hoaxes described above, it should suffice to show that sometimes a knowledge of the facts of science was all it took to debunk a hoax, as in the case of chemistry, invisible inks, and slate writing. Edward Livingston Youmans was certain that knowledge of anatomy, the physiology of the nervous system, and pathology would allow people to make decisions about the verity of "the whole domain of mysticism, upon which the public are actually mad, viz., biology, magnetism,

[326] Ibid.
[327] Carpenter, *Mesmerism*.
[328] Robinson, *Spirit Slate Writing.*

spiritism, etc."[329] Other times it took logical scientific reasoning to debunk a hoax, as in the case of William Carpenter, the scientist who described the debunking of dark séances with the use of blue ink on the medium's hand. Finally, in other cases, a knowledge of the theories of science helped to debunk a hoax, as in the case of physiological science and mesmerism, employing an understanding of the excitability of the nervous system, self-deception, and dispositions that tended to believe in occult agencies. The main point here, to reiterate, was that a scientific education, where students learned both the facts of science and how to think like a scientists, was an early remedy against scientific hoaxery.

Nature of Science

Teaching science in order to combat quackery relied heavily on teaching different aspects of the nature of science. One such dimension of the nature of science was gaining the ability to detect poor science, or, in other words, to understand what is and what is not science.

This is what William Carpenter had to say about hoaxery:

> And so it always proves *in the end* [all italics in the original] with these *sham* marvels; which, however specious they may appear at a distance, vanish under critical investigation like the *mirage* of the desert on nearer approach. The *real* marvels of science, on the other hand, not only stand the test of the most critical examination, but prove more marvelous the more thoroughly they are investigated.[330]

The force of od, part of the theory of odylism, was an example of a sham marvel that could not hold up to scientific investigation. Scientific tests could not be performed to prove the existence of od because the examples of the force of od were all subjective and occurred solely in the bodies of sensitive individuals. The study of the nature of science demonstrates that science

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[329] Fiske, *Edward Livingston Youmans*, 83.
[330] *Mesmerism*, 84.

demands evidence and accurate data, and people who understand this may be more apt to determine that something like odylism cannot provide acceptable data.

The simple act of expressing doubt and asking for substantiating data when presented with a new scientific phenomena was another aspect of the nature of science that could help to combat quackery. That onlookers never expressed or even entertained doubt as to the truth of things like table-lifting and mesmerism was a concern of Gilded Age scientists. Josiah Cooke exemplified this opinion when we wrote, "So that when new conquests over matter are announced, and great discoveries are proclaimed, [the public] may be able not only to understand but also to criticize the methods by which the assumed results have been reached, and thus be in a position to distinguish between the true and the false."[331] Cooke made an important point about distinguishing between the true and the false, and although he did not use the term nature of science, he clearly had the nature of science in mind in his discussion. Cooke also echoed George Paget's example, pointed out in *CDML*, that real science seemed so unbelievable that people were unsure of what was and was not science and had no way of distinguishing between real science and false science.[332] Again, teaching students science in the secondary schools, particularly teaching them aspects of the nature of science, was a way to educate people to distinguish between real and pseudo-science.

People were dazzled by science in the Gilded Age, with incredible things like electric lamps and railroad trains resulting from scientific understanding. The power of science and technology had captured the popular imagination and its scope seemed unbounded. Strangely, people seemed to have understood one aspect of the nature of science, namely that science was far from having unveiled all of the mysteries of nature; unfortunately, this understanding led

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[331] Cooke, *Scientific Culture*, 17.
[332] "Influence of Scientific Culture."

them to willingly accept any new discovery made under the name of science.[333] The historian Matthew Goodman made a good point, writing that if tiny molecules could be detected in a single drop of water, then why would it not also be possible to detect astonishing creatures on the moon?[334] In other words, real scientific discoveries were so extraordinary that equally extraordinary pseudo-scientific "discoveries" would be hard to distinguish. This, of course, was exactly the point the Gilded Age scientists were arguing – a scientific education, one that taught students about the nature of science, would help people to determine what was and what was not real science.

One of the ways people would be able to distinguish between real scientific facts and phenomena and false science was via an understanding of what it takes to make a scientific claim and a scientific conclusion, how one goes about establishing a scientific fact, and the weight and value of a body of evidence. These are further aspects of the nature of science that Gilded Age scholars claimed could help put an end to scientific hoaxery.

The key word in the discourse here was *evidence*. First and foremost, the public should demand credentials from those offering new scientific discoveries and evidence supporting any claims.[335] This was an aspect of a scientific mind that would serve not only to detect scientific fraud but would also serve in everyday life and everyday topics, not even necessarily scientific topics. One important point here was that people often did not know who had the authority to speak on certain subjects and who did not. Even scientists talked about science outside their own area of expertise, as in the case of Lord Kelvin, a renowned Gilded Age physicist who debated about the geologic age of the earth even though this was outside of his physics and engineering background. In fact, Lord Kelvin won over some converts to his point of view simply due to

[333] Carpenter, *Mesmerism*.
[334] *Sun and Moon*.
[335] Chamberlin, *Address*.

deference to authority, since "Lord Kelvin is the highest authority in science now living."[336] This affair exemplifies the disability among the public to know who has the authority to speak about certain subjects, where Lord Kelvin was given authority by the public to speak about all things scientific even though his expertise was only in physics and engineering.

John Stuart Mill also saw the educational advantages of a scientific education that taught students how to determine who had authority to speak on certain topics. He said:

> But unless an elementary knowledge of scientific truths is diffused among the public, they never know what is certain and what is not, or who are entitled to speak with authority and who are not: and they have either no faith at all in the testimony of science, or are the ready dupes of charlatans and impostors. They alternate between ignorant distrust, and blind, often misplaced, confidence.[337]

Demanding the credentials of those presenting new discoveries and demanding evidence to prove the truth of new scientific facts was not only a point about combating scientific hoaxery. This also went back to the argument that the classics as a discipline habituate the mind of the learner to dogmatism and acceptance without inquiry.[338] A scientific education, particularly one that incorporated the nature of science, would teach students to question things brought before them, both hoaxes and other non-scientific things in their everyday lives. It would also teach them to place their confidence in the right people.

One aspect of questioning new discoveries was that a scientific mind should be able to weigh the evidence, consider every degree of probable evidence, and eliminate all accidental phenomena as possible causative factors.[339] Furthermore, a scientific habit of mind could prevent

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[336] Twain, *Letters from the Earth*, as cited in Burchfield, *Lord Kelvin*, ix.
[337] Mill, "Inaugural Address," 233.
[338] Wilson, "Natural Science in Schools."
[339] Chamberlin, *Address;* Cooke, *Scientific Culture*; and Fiske, *Edward Livingston Youmans*.

against succumbing to hoaxery by teaching one to avoid errors of prejudice. What was meant here was two things, firstly that a judicial attitude of mind would give fairness to all evidence, and secondly that disturbing influences of personal bias and personal feelings would not get in the way of a proper judgment.[340] One's personal desires to seek certain evidence (e.g., that mesmerism could cure your gout) should, if one were trained early in a scientific way of thinking, not cloud one's judgment about the veracity of a new discovery.

One final aspect of the nature of science that was an important part of a scientific education that would combat hoaxery was that a scientific mind should withhold conclusions until sufficient evidence is brought forth. In the case of scientific hoaxes such as table-rapping, this might mean withholding one's conclusions when there is insufficient evidence. The fact that one cannot see where the rapping sounds are coming from does not immediately imply that they are coming from spirits, and a properly trained scientific mind should ask for evidence, weigh all of the given data, and make a conclusion only when sufficient data is available. If the public could do this for each hoax they saw, it might go a long way in eradicating scientific hoaxery, at least in the minds of the Gilded Age scientists and scholars cited here.

Scientific Fraud as Relates to Scientific Literacy

As the preceding sections of this chapter have shown, the discourse seen in *CDML* was a product of the times, where the prevalence of false science being presented to the public necessitated a scientific education that taught people how to detect false science and how to debunk hoaxery for themselves. The analysis in the preceding sections of this chapter has also shown that the discourse found in *CDML* was being echoed in the larger intellectual arena, where scientists like Josiah Cooke, John Stuart Mill, and James Wilson were also concerned with

[340] Chamberlin, *Address;* and Fiske, *Edward Livingston Youmans*.

scientific hoaxery, and where scholars like William Carpenter took it upon themselves to educate the public about the untruthfulness of certain hoaxes.

Following from my claim that the discourse in *CDML*, by pulling together the ideas of a variety of scholars, framed a comprehensive view of science education for the first time in the history of education in the United States, the discourse in *CDML* is being treated as a representative sample of thought during the Gilded Age. As noted in the previous two chapters, I paid special attention to points that may have laid some foundations for our modern day notion of scientific literacy as I analyzed the discourse in *CDML*. By analyzing the discourse through a modern day lens of scientific literacy, I can gain greater insight into the discourse, a deeper analysis of it, and a way to organize my thinking about it. For an in-depth review of the current discourse on scientific literacy, please refer to Appendix A.

Within the discourse in *CDML* only a handful of scholars were concerned about scientific hoaxery and used it as an arguing point for advocating teaching science in the secondary schools. With that said, those who did concern themselves with this topic, Michael Faraday foremost among them, were passionate about it. Many of the rationalizations put forth by Gilded Age scholars for teaching science to combat hoaxery have correlations with our modern day notions of scientific literacy. As with previous chapters, this discussion will be organized according to the nuances found in the modern day literature on scientific literacy.

Social Responsibility

This nuance in the modern day literature on scientific literacy covers those things that relate to responsible and active citizenship such as being able to understand scientific issues one reads in the media, being able to discuss these issues knowledgeably, and, moreover, being able to make informed democratic decisions about scientific issues.[341]

Scientific literacy includes being able to make informed decisions about scientific and technological issues that are in the national public agenda. In other words, scientific literacy involves using decision-making skills for scientific issues.[342] Today's controversial socio-scientific issues like genetic engineering and nuclear power were not on the minds of the Gilded Age scholars discussed in this chapter; they were instead concerned with socio-scientific topics like mesmerism and table-turning. This does not, however, devalue their need for scientific literacy. In both the past and the present, scientific literacy involves using decision-making skills by common people for the purpose of understanding scientific issues, regardless of whether the issue is acid rain or the pasilalinic sympathetic compass. In the case of Gilded Age concerns, a scientifically literate citizen would be able to determine for him or herself the verity of any given hoax.

Today, part of being able to make informed decisions about scientific issues in the public agenda is being able to understand discussions of these things in the popular media.[343] While Gilded Age citizens did not hear about clairvoyance on the nightly news, they did have sources of popular media like the newspaper where they may have heard about scientific claims. More likely though, Gilded Age individuals would have discussed scientific hoaxery around the dinner table or in the drawing room with someone who had personally experienced one hoax or another. Then, as now, the scientifically literate individual would be able to understand the scientific

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341 DeBoer, "Scientific Literacy;" Ewing et al., "Improving Student Attitudes;" Glynn and Muth, "Reading and Writing;" Hurd, "Scientific Literacy;" Koelsche, "Scientific Literacy;" Kolstoe, "Consensus Projects;" Lee and Roth, "Science and the 'Good Citizen';" Meehan, "Nuclear Safety;" Miller, "Scientific Literacy;" Oliver et al., "The Concept of Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.
342 Hurd, "Scientific Literacy;" Kolstoe, "Consensus Projects;" Lee and Roth, "Science and the 'Good Citizen';" Meehan, "Nuclear Safety;" Miller, "Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.
343 DeBoer, "Scientific Literacy;" Ewing et al., "Improving Student Attitudes;" Glynn and Muth, "Reading and Writing;" Koelsche, "Scientific Literacy;" and Oliver et al., "The Concept of Scientific Literacy."

things they heard about, wherever their information was coming from. By knowing what it means to call something a law of nature, understanding what kinds of evidence and reasoning it takes to make a scientific conclusion, and understanding what it takes for others to construct convincing arguments would have all been important things for a scientifically literate person to know in order to understand what they read in the newspaper or heard around the dining table about something like odylism for example.

What is more important still than being able to understand and interpret scientific discourse in the mass media (or out at dinner or sitting in front of a stage show) is being able to evaluate and make critical judgments about science and scientific authority. Today *SFAA* calls this "informed skepticism" and even makes a reference to hoaxery, writing that a scientifically literate person would be able to distinguish between scientific and pseudo-scientific questions, allowing them to combat "dogmatists, flimflam artists, and purveyors of simple solutions to complex problems."[344] The language in *SFAA* sounds similar to that of the Gilded Age, and while the Gilded Age scholars did not use the term scientific literacy, they clearly had something similar in mind to the AAAS, where a science education would help discourage scientific hoaxery.

For some scholars today, the ability to make critical judgments about scientific authority involves knowing when to seek expert advice and where to find access to responsible expert advice.[345] This may be likened to knowing to ask a hydrologist (rather than a medical doctor) questions about river flow dynamics. In the case of hoaxery in the Gilded Age, this meant knowing who was and was not able to make conclusions about new scientific discoveries. For example, the scientifically literate person would know to ask a scientist about the authenticity of

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[344] AAAS, *SFAA*, 186, xiv.
[345] DeBoer, "Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.

electro-biology rather than blindly taking the word of the stage performer hypnotizing someone on stage.

Organization of Knowledge

According to the modern day literature on scientific literacy, the organization of scientific knowledge includes understanding the process of science, knowledge of the facts and principles of science, and acquiring the skills of science. None of the scholars reviewed for this research (please see Appendix A) would consider the organization of scientific knowledge as the sole purpose or criterion of scientific literacy; rather, the organization of scientific knowledge is merely a necessary component of the scientifically literate person.

Knowledge and understanding of the basic facts and principles of science (e.g., motion and electromagnetic forces) and a knowledge and understanding of the basic vocabulary of science (e.g., cardiovascular, centigrade) is one aspect of the organization of knowledge, and thus one facet of a scientifically literate individual.[346] Some of the Gilded Age scholars explored in this chapter like William Carpenter and Michael Faraday would agree with this sentiment.[347] In the example of table-turning, both Newton's First Law (i.e., A body persists its state of rest or of uniform motion unless acted upon by an external unbalanced force.) and Newton's Third Law (i.e., To every action there is an equal and opposite reaction.) were being violated, but people did not know enough science to realize this fact. For his part, Thomas Henry Huxley was convinced that spirit-rapping and table-turning were purely physiological phenomena, and that the public's utter ignorance of the simplest laws of animal life allowed them to be taken in by these hoaxes.[348] The scientifically literate person who understood the major concepts and vocabulary

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[346] AAAS, *Benchmarks; SFAA*; and NRC, *Standards.*
[347] Carpenter, "Extracts;" and Faraday, "Education of the Judgement."
[348] *Science and Education*.

of science may have been able to debunk for himself some of the more outlandish hoaxes that defied nature's laws.

In the modern day literature on scientific literacy we find that scholars include scientific ways of thinking as another facet of the organization of knowledge and thus as another characteristic of the scientifically literate individual. These skills include such things as analyzing, interpreting, classifying, predicting, controlling variables, and using both deductive and inductive reasoning. Acquiring these various scientific ways of thinking will encourage students to become independent and logical thinkers who are good at problem-solving.[349] In the case of Gilded Age hoaxery, the scientific skill of critical thinking was one aspect of scientific literacy that can be found in the discourse. While the Gilded Age discourse may not have directly referenced any of these skills, we can find examples with the implications of such. Herbert Spencer wrote that, "The constant of drawing conclusions from data, and then of verifying these conclusions by observation and experiment, can alone give the power of judging correctly."[350] J. H. Brown's discourse on the anatomy of the eye and the nature of light used predicting and controlling variables to prove that myodesopsia, or deposits of various size, shape, consistency, refractive index, and motility within the eye's vitreous humour, which is normally transparent, was often responsible for the seeming glimpse of spectral illusions.[351] A scientifically literate individual would find something quite amiss at a dark séance where the presentation disallowed for controlling variables to determine the authenticity of the séance. Finally, simple inductive reasoning led one scientist to determine that the medium with blue ink on his hands was, in fact, the same individual as the spirit who appeared in the dark.

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[349] Fensham, "Science for All;" Glynn and Muth, "Reading and Writing;" Koelsche, "Scientific Literacy;" Palincsar et al., "Pursuing Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.
[350] *Education*, 84.
[351] *Spectropia.*

Conclusion

To review, the main argument explored in this chapter was that teaching students science was an effective way to combat widespread scientific fraud. Michael Faraday, the most outspoken scientist on this point, urged that we should educate the judgment. What he meant by this was, in effect, giving students all of the tools necessary to think for themselves (and debunk scientific hoaxes themselves if they so wished). A basic knowledge of the facts of science was sometimes enough to debunk a hoax, other times thinking logically was enough. More often than not, though, scholars reviewed in this chapter advocated for teaching various aspects of the nature of science in order to combat scientific quackery. This included expressing doubt and insisting on evidence when confronted with a scientific claim, understanding what it takes to make a scientific claim and establish a scientific fact, understanding the weight of a body of evidence, and understanding something of the uncertainty in science. Ultimately these multiple abilities would allow people to distinguish between science and pseudo-science, which was particularly important in a world where people were dazzled real science, and where new scientific discoveries were often more unbelievable than false scientific claims.

In conclusion, scientific hoaxes were truly widespread in the Gilded Age society. While scientists may have felt that hoaxery was harmful to the public, for the most part some innocent stage hypnosis and table lifting did not do bodily harm to people. The same cannot, however, be said of medical hoaxery during the Gilded Age. The art of medicine and the professionalizing of the occupation were coming into their own during the Gilded Age, and aspects of health and medicine were also on the mind of scholars advocating for science education. Issues of public health, one of which was medical fraud, were another concern of the Gilded Age scholars found in *CDML*, and it is to this topic that we now turn.

Dr. S. P. Townsend's Compound Extract of Sarsaparilla. The Wonder and Blessing of the Age, The Most Extraordinary Medicine in the World! This Extract is put up in Quart Bottles; it is six times cheaper, pleasanter, and warranted superior to any sold. It cures without vomiting, purging, sickening or debilitating the Patient.

Armstrong & Armstrong, *American Medicine Show*

CHAPTER 5

PUBLIC HEALTH

Introduction

This chapter will be presented in a manner similar to the previous three chapters, where the discourse in *CDML* is used as a foundation. The discourse will then be examined and analyzed utilizing other Gilded Age literature and various secondary sources from both the twentieth and twenty-first centuries. As such, in the first section of the chapter the arguments found in *CDML* will be laid out as they appear in the edited chapters of that book, with discussion and elaboration being saved for the second section of the chapter. Finally, in the third section of the chapter the Gilded Age discourse will be examined through the lens of our modern day notions of scientific literacy.

In this chapter I consider those arguments relating to public health issues. This is a multifaceted chapter, with three distinct threads, each of which pertains to public health concerns. First, concerns about health, hygiene, sanitation, and disease are explored, with a look into the sanitary conditions of Gilded Age living and discussions on how a scientific education could improve sanitary, health, and hygiene conditions as well as teach people about disease and disease prevention. Secondly, medical quackery of the Gilded Age is examined, where some of the popular hoaxes are described. As with scientific hoaxery seen in the previous chapter, medical hoaxery is examined as relates to how a scientific education could help combat the widespread occurrence of medical fraud. Finally, concerns about the medical field are explored. Particular attention is paid to the discourse on medical school education and the preparation of students before they arrive at medical school. Also examined is discourse on the social status of Gilded Age physicians, where science education is seen as a remedy for the poor social standing of physicians.

Public Health as Seen in *Culture Demanded by Modern Life*

This chapter will explore three discrete arguments for teaching science in the schools, each of which is related to public health. The authors of chapters within *CDML* frequently made reference to this special subset of what were most commonly categorized as public health issues. The first argument focused on issues related to health, sanitation, and hygiene, claiming that science education (often specifically physiology) would increase people's knowledge and understanding of these issues, which would ultimately improve public and personal health conditions. The second argument focused on medical quackery, similar to the arguments seen in Chapter 4, "Scientific Fraud." Here a subset of scientific hoaxes that were specifically aimed at medical issues will be explored. These hoaxes had special significance for public health. Finally, the third argument focused on issues related to the medical field, including improving the education of medical students (both before and during medical school), and improving the social standing of doctors. Not surprisingly, most of the scholars most keenly involved in the discourse about public health had medical backgrounds. For example, Henry Acland was a medical professor at Oxford University, Richard Owen was an anatomist, George Paget had a medical career, and James Paget was a surgeon and a pathologist.

James Paget, one of the chapter authors within *CDML*, might have put the argument for teaching science for the sake of one's health most succinctly when he wrote, "Every one should learn somewhat of the structure of the human body, and of the processes that are carried on within it."[352] The study of science, physiology in particular, would help people to maintain their health by giving them an understanding of what factors control their health and teaching economy of one's powers. James Paget's brother, George, claimed that natural science would give students knowledge of their health, thus improving their lives.[353] Similarly advocating for science education as a means of improving one's health, William Hodgson made the point that people must be taught to take air for their health because things like that were not learned elsewhere.[354] James Paget wrote that opponents of teaching science argued that nature and instinct would tell a man how to maintain his health, so teaching about it in school was unnecessary. Paget argued against this, writing that we cannot rely on nature to help maintain our health, that both the senses and the instinct must be educated. He gave examples of his point, writing that our senses cannot discern deadly gases and that hunger tells us nothing of the nutritional value of food.[355] These Gilded Age scholars were advocating for preventative health education when they argued that a scientific education would help students better understand and be able to deal with their own wellness.

More importantly than one's everyday health though was an understanding of disease. None of the scholars in *CDML* gave reference to the state of disease theory during the Gilded

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[352] "Study of Physiology," 149.
[353] "Influence of Scientific Culture."
[354] "Study of Economic Science."
[355] "Study of Physiology."

Age, but the germ theory of disease (that illnesses were born by germs rather than by noxious gases or putrefactive odors) did not gain widespread public acceptance until after the end of the Gilded Age. Nevertheless, at least Edward Livingston Youmans and Henry Acland saw the educational value of teaching people about disease, disease prevention, and hygiene.[356] William Hodgson, one of the scholars without a medical background (Hodgson was a Scottish economist), also advocated teaching about disease prevention. His reasoning for supporting the teaching of disease prevention stemmed from the fact that prophylactic elements of medicine were, at the time, receiving more attention than therapeutic elements of medicine.[357]

Sanitation was another aspect of public health that Gilded Age scholars considered. Two specific issues, disease prevention as a key to health and improvement of city living conditions, were developed by authors within the chapters of *CDML*. Edward Livingston Youmans advocated for the teaching of physiology as a means to this end. He wrote: “The value of such knowledge for daily use has been made familiar to us all by the sanitary discussions of late years.”[358] Henry Acland concurred on the prevalence of sanitary discussions in society, writing, “Sanitary inquiries, of all kinds, now come within the range on town-councils and officials in every class of society.”[359] Using a tangible example of the benefits of teaching science for the sake of sanitary improvement, George Paget gave the example of decreased infant mortality that had recently resulted from sanitary science knowledge.[360] Further advocating for the teaching of science in order to address sanitary issues, William Hodgson wrote that pestilence in slums affects the whole city, so everyone should learn something about the laws that govern one’s

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[356] Acland, “Early Physiological Study;” and Youmans, “Mental Discipline in Education.”
[357] Hodgson, “Study of Economic Science.”
[358] “Mental Discipline in Education,” 37.
[359] “Early Physiological Study,” 450.
[360] “Influence of Scientific Culture.”

health.[361] By addressing such concrete issues as health and sanitation, the scholars in *CDML* brought their heretofore academic arguments to a more pragmatic level.

A second line of reasoning used to promote science education for public health concerns was as a deterrent against medical hoaxery. The argument here was quite similar to that seen in the previous chapter, "Scientific Fraud." Apparently both laypeople and doctors, who were often poorly educated in science at the beginning of the Gilded Age, were equally likely to be taken in by medical hoaxes, and presumably a scientific education would help quell this predicament.[362] Quack medicine was just as much of a problem in society as other scientific hoaxes (e.g., table-turning, clairvoyance, hysteria), and people's lack of scientific understanding was viewed as providing increased encouragement to medical hoaxsters to make even more outrageous claims. Richard Owen, for instance, claimed that the lack of scientific knowledge allowed for "the success of spurious systems of medicine."[363] His point, like those made by many of the scholars examine in the previous chapter, was that a scientific habit of mind would help people to question the veracity of bold medical claims. Both Henry Acland and William Hodgson felt that a scientific education, particularly one that taught the facts of sciences such as anatomy and physiology, would prevent medical quackery. They claimed that even a basic knowledge of the mechanics and chemistry of one's body would do much against false medicine.[364] As with the scientific hoaxes in Chapter 4, scholars in *CDML* did not explain specific medical hoaxes, so that will be left for later in this chapter when I look at literature both from the Gilded Age and from the twentieth century.

[361] "Study of Economic Science."
[362] Paget, J., "Study of Physiology."
[363] "Extracts," 468.
[364] Acland, "Early Physiological Study;" and Hodgson, "Study of Economic Science."

A third line of argument used to promote science education for public health concerns was in reference to the medical field (the legitimate medical field, as opposed to medical quackery) and medical schools. Joseph Hooker was concerned with the time wasted in medical school teaching basic science such as botany and chemistry.[365] Hooker's remedy for this would be to teach science in the secondary schools so that medical students would come to medical college with a basic understanding of science. This is not a surprising statement from Hooker, who was himself a botanist, for it would seem that Hooker, by advocating for teaching subjects like botany to premed students, was advancing the teaching of his own scientific subject of expertise.

George Paget, himself a member of the medical field, saw the value of scientific knowledge for those who wished to enter the medical field not just as an advantage for medical school but because, "without scientific knowledge, the practice of medicine becomes mere empiricism."[366] Paget went on to say that medicine was founded on truth and reason, not mystery. Presumably a scientific education would demonstrate this to both future doctors and patients. James Paget mentioned one counterargument to teaching science, particularly physiology, that people would be led to be their own doctors. He dismissed this idea as foolish, and Edward Livingston Youmans agreed, writing that by teaching people something about their bodies, health, and disease, they would be more knowledgeable about when they did and did not need medical treatment.[367] So, rather than causing people be their own doctors, a scientific education would make them more knowledgeable patients.

A science education in the secondary schools, before entrance to medical school, would also help doctors to train their powers of observation, which were so important in the hospital

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[365] "Extracts."
[366] "Influence of Scientific Culture," 422.
[367] Paget, J., "Study of Physiology;" and Youmans, "Mental Discipline in Education."

and when visiting patients.[368] George Paget argued that physicians who knew the basic laws of science (beyond those necessary for medical care) would also be able to prevent the spread of errors by passing on their knowledge to their patients, giving their patients more confidence in true medicine as opposed to quack medicine.[369] The unscientific reputation of many doctors was a problem, and people distrusted and disrespected doctors. Prevalent practices, especially ones that were often more harmful than helpful such as bloodletting, may not have helped the social authority of doctors, and a more scientific tone in their practices might have helped improve the social influence of doctors.

In summary, there are three distinct but related arguments that can be pulled out of the discourse in *CDML* as relates to science education for public health. One issue was that of health, sanitation, and hygiene. Seemingly separate concerns, health, sanitation, and hygiene issues all dealt with teaching people something about their bodies, their health, and disease. Using science education to address public health issues was one argument that often revolved around a specific science discipline, physiology in this case. (Most of the other arguments explored in this research were not discipline specific, meaning that any given science discipline could achieve the desired results.) Physiology could give students an understanding of the mechanics and chemistry of their bodies as well as an understanding of disease and disease prevention. Another issue explored in this chapter was that of medical hoaxery, which was similar to most other types of scientific hoaxery. A scientific education would teach people how to detect scientific fraud, who had authority to make medical claims, and the range of possibilities and impossibilities in medicine. A final issue as pertains to public health was that of the medical field. Science education would improve the medical field by giving medical students a leg up in medical

[368] Hooker, "Extracts."
[369] Paget, G., "Influence of Scientific Culture."

school, it would improve their observation powers, it would help them to educate their patients about medical issues, and it would lend the medical field as a whole credibility and respect.

Public Health as seen in Other Literature

Health and Disease

Herbert Spencer, in his well-known essay, "What Knowledge is of Most Worth?", came to the conclusion: "Thus to the question with which we set out – What knowledge is of most worth? – the uniform reply is – Science."[370] This conclusion was, of course, Spencer's aim in writing the essay and the most significant point made by the essay. What is less well known, however, is that Spencer listed in order of importance five different purposes of education, all of which led to the conclusion that science was worth the most; the very first item listed, the most important purpose of education, was to prepare students for direct self-preservation, meaning guarding the body against damage and destruction, injury, disease, and death. In other words, as far as Spencer was concerned, teaching science in order to help students preserve their health was the most important function of a science education. Thomas Henry Huxley felt much the same way, writing that "the most necessary branch of instruction" was that "which teaches them how to avoid disease and to cherish health."[371] Further lending credence to the importance of education for self-preservation, Delos Fall, a Gilded Age member of the Michigan Board of Health, wrote "An eminent prime minister of England once said, 'The health of the people is the first duty of the Statesman.'"[372] From these examples, one finds that science education to promote health was a significant concern of Gilded Age scholars. Physiology was specifically mentioned as an answer to science education to promote health. It would give students an understanding of the constitution and modes of action of the living body as well as an

[370] *Education*, 89.
[371] *Science and Education*, 60.
[372] Fall, "Sanitary Science," cxxxi.

understanding of the nature of health and disease.[373] Natural history was another suggestion, as this subject too would afford many observations relating to the preservation of health.[374]

A modern day researcher may wonder at the conditions that led to this rally for education for the sake of health. Armstrong and Armstrong, writing at the end of the twentieth century, called the personal habits of people at this time "disgusting" - they ate and drank themselves silly, there were no good hospitals, sickrooms were shuttered and stifling, beds were overrun with vermin, and people did not wash their clothing.[375] Personal hygiene and public sanitation were virtually non-existent at the beginning of the Gilded Age, and this was a major cause for concern and reform among many Gilded Age individuals.

Two present day public works historians, Stanley Schultz and Clay McShane, gave us some insight into living conditions during the Gilded Age. They wrote, "of the many crises confronting nineteenth century urbanites, none loomed more obvious or important than environmental pollution."[376] Few streets were paved, there was little if any garbage collection, horse excrement lay in the streets, soot from factory buildings covered things, there were open ditches, overflowing cesspools, accumulations of foetid matter, heaps of rubbish, and noisome smells, to name a few of the environmental pollutions of the Gilded Age.[377] In terms of city lodgings, "dumbbell buildings" were the design of choice in Gilded Age New York City for lost-cost and space-saving tenement housing, so called for the long narrow airshaft running through the middle of the building. The shafts, unfortunately, merely served as a receptacle for garbage, filth, and refuse of all kinds, all of which remained rotting at the bottom of the shaft.[378]

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[373] Huxley, *Science and Education*.
[374] Cloyd, *Benjamin Franklin*.
[375] *American Medicine Show,* 3.
[376] "Engineer the Metropolis," 390.
[377] Ibid.; and Beder, "Pipe Dreams."
[378] Center for the History and Ethics of Public Health, "1870s."

Before the 1870s the typical sanitation method to dispose of human waste and wastewater was called the "cesspool-privy vault," where waste was discharged onto land adjoining one's home or shop. Human waste was dumped into privy vaults, while wastewater was dumped into cesspools, both of which were holes in the ground that were only sometimes lined with stone.[379] Cesspits and privies would inevitably overflow since there was almost no collection of waste from these holes, polluting waterways and streets and seeping into groundwater wells.[380] The "water-carriage" system of waste and sewage removal, founded in the 1850s, gained a permanent foothold in the 1870s. This sanitation method involved the movement of human waste and wastewater through a pipe, with the "wastewater itself as a transporting medium and as a cleansing agent in the pipe."[381] According to one twentieth century historian, until around the time of the Gilded Age, people were resigned to dirt, pollution, and grime. Not surprisingly, at this point in time disease was seen as punishment from God.[382]

During the Gilded Age there was an increasing interest in public health, in the restriction and prevention of disease, and in sanitary science. People had become weary of one epidemic after another – in 1896 in Michigan, the eight most devastating diseases, in order of number of deaths caused, were consumption (now known as tuberculosis), pneumonia, diphtheria, typhoid fever, scarlet fever, measles, whooping cough (also known as pertussis), and smallpox.[383] Other epidemic diseases that ravaged the population during the Gilded Age included yellow fever, Asiatic cholera, and typhus (not to be confused with typhoid fever).[384] Thanks to a better understanding of infectious disease that was created and disseminated during the latter half of the

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379 Peterson, "Sanitary Reform;" and Tarr et al., "Water and Wastes," 228.
380 Beder, "Pipe Dreams."
381 Peterson, "Sanitary Reform;" and Tarr et al., "Water and Wastes," 233.
382 Beder, "Pipe Dreams."
383 Fall, "Sanitary Science."
384 Peterson, "Sanitary Reform."

Gilded Age, the germ theory of disease (i.e., microorganisms are the cause of many diseases) and ensuing hygiene and sanitation reform were able to take hold at the end of the time period.

The sewer gas theory of disease judged that decaying organic matter (e.g., human and animal waste) exuded odorless gas that caused infectious illnesses.[385] Similarly, the filth theory of disease judged that putrefactive odors (also known as "miasmas") caused infectious illnesses, in this case the odors could emanate from decomposing organic matter, stagnant water, sodden ground, impure drinking water, or spoiled air.[386] Both of these theories assumed an anticontagionist viewpoint, where disease was transmitted by impure air. Most doctors during the Gilded Age were of this opinion, in contrast to the contagionist view, where disease was transmitted by contact.[387] John Snow, an early contributor to the contagionist theory, showed through rigorous scientific methods that the 1854 cholera epidemic in south London was caused by impure drinking water not impure air.[388] With that said, the anticontagionist viewpoint still dominated medical thinking for much of the Gilded Age.

It is interesting to note that *CDML* was published at the beginning of the Gilded Age, when the anticontagionist view and the filth theory of disease prevailed, and before the sanitary reform movement of the 1880s. Even though we now know that the scientists were laboring under incorrect assumptions about the causes and spread of disease, they still saw the need to educate the public about illness and sanitation. Physiology could teach students about the importance of understanding the true conditions of health and disease, according to John Stuart Mill.[389] More specifically, the arguments of the day suggested that people should be taught the most commonly occurring diseases, their premonitory symptoms, their specific causes, their

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[385] Schultz and McShane, "Engineer the Metropolis."
[386] Beder, "Pipe Dreams," 31; and Peterson, "Sanitary Reform."
[387] Beder, "Pipe Dreams;" and Tarr et al., "Water and Wastes."
[388] Snow published widely on the topic of the spread of cholera. See Snow, "Cholera" as an example.
[389] Mill, "Inaugural Address."

method of spreading, and various methods of prevention; also important was education about infection, contagion, isolation, and disinfection.[390] If nothing else, the public should have some knowledge of anatomy and physiology to understand what they read and heard in the popular media about disease and sanitation.[391]

Although scientific disciplines such as anatomy and physiology were suggested as appropriate sciences to learn in order to inform the public regarding health and disease prevention, it was more common, particularly toward the end of the century, for the study of hygiene to be the recommended solution.[392] Richard Hofstadter, in this mid-twentieth century history of anti-intellectualism in America, made an interesting point about the teaching of hygiene in the schools. In his opinion, the teaching of hygiene was another example of anti-intellectualism in the American schools, where school policy-makers thought that elementary hygiene was more important than developing the mind.[393] Hofstadter's point appears valid; the argument made for teaching science in order to address public health issues certainly does not seem to have fit in with the scientists' principal argument, namely that science could fulfill the current purpose of education of training the mind. In this case, those who accused the scientists of vulgar utilitarianism may have had something to their claims; teaching students how to prevent disease seems rather utilitarian in nature.

With that said, the scholars whose work has been investigated in this research were ultimately trying to include science in the school curriculum. They used multiple arguments to make their case, and if the argument to teach science in order to combat epidemic diseases was an effective argument, although admittedly only a minor argument, the scholars clearly did not

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[390] Fall, "Sanitary Science."
[391] Huxley, *Science and Education*.
[392] Fall, "Sanitary Science."
[393] *Anti-Intellectualism.*

shirk from using it. In Chapter 3, "Functional Education," it was concluded that the scientists' main argument for including science in the curriculum was that science could both fulfill the status quo purpose of education of training the mind while at the same time preparing students for life by giving them useful knowledge to live in a scientific world and useful scientific skills to use in their lives. While sanitary science and hygiene (although that term really refers to a set of practices rather than a branch of science) would not necessarily train the mind, they would prepare students for life outside of school. Furthermore, physiology and natural history were claimed as sciences appropriate to meet the need of public health concerns; these sciences could train the mind as well as prepare students for life outside of school. In fact, John Snow's work on determining the cause of the 1854 cholera outbreak in south London was an early example of the science of epidemiology, a science that, if taught in schools, would train the mind via its methodology of generating theories, testing hypotheses, and making educated guesses about correlation and cause of disease spread.[394] Although, as noted above, Snow's work did not come in to widespread acceptance until later in the Gilded Age, some of the scholars examined here did advocate for teaching things quite similar in nature to epidemiology, namely the methods of disease spreading, isolation, and prevention.[395] So the base utilitarianism of teaching students hygiene and disease prevention may have had some implications for training the mind as well. In any event, the public health crisis was of such consequence that protecting people's health and lives might have been more important than any other function of education.

Medical Quackery

As with the scientific hoaxes detailed in Chapter 4, "Scientific Fraud," medical hoaxes were rampant in Gilded Age society. Importantly, as with certain of the scientific hoaxes

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[394] MacMahon, *Epidemiology*; and Morabia, *History of Epidemiological Methods*.
[395] Fall, "Sanitary Science;" and Mill, "Inaugural Address."

presented in the previous chapter, while many medical hoaxes were perpetrated with the willful intent to deceive and defraud, surely some of the schemes to be discussed below were put forth in good faith, where the purveyors of these medicines truly felt that their treatments were efficacious. It is also worth noting that most of my sources of information about scientific hoaxes are from the Gilded Age, while all of my sources of information about medical hoaxes are from the present-day, thus lending these authors the gift of hindsight. For this reason, and because neither the men in *CDML* nor the other Gilded Age scholars examined in this section on medical hoaxery specifically named any medical hoaxes, it is unclear if the Gilded Age scholars themselves felt that the medical hoaxes to be presented below were, in fact, false medicine. With that said, the medical hoaxes to be explained below should serve merely as illustrations of medical hoaxery in the Gilded Age.

While the Gilded Age scholars explored here may not have given specific examples of medical hoaxery, they did make clear arguments for teaching science in order to combat medical hoaxery, and these arguments were quite similar to those made for teaching science in order to combat scientific hoaxery. Points that served both to combat scientific hoaxery and medical hoaxery included teaching students how to think like a scientist, giving them the mental tools necessary to debunk a hoax, giving students an understanding of what it takes to make a scientific (or medical) claim, giving students an understanding of the difference between science and pseudo-science, and giving students enough scientific facts to debunk false claims.

As noted above, many Gilded Age physicians were trained via apprenticeship and thus did not carry formal credentials. This situation necessitated that patients rely on their sense of trust of their physicians, and the unfortunate result of this was that hoaxers could easily take advantage of people. Charlatans could purchase medical degrees from diploma mill colleges without even going to medical school, although a medical degree was not even necessary in order to call oneself a physician.[396] Medical hoaxsters also had an easy time because real medical practices like bloodletting, purgatives, and blistering were so brutal that people easily took to less savage (but also often less effective and less scientific) medical practices.

Here follows a brief explanation of some medical hoaxes from the Gilded Age:

Hydropathy was a cold-water therapy meant to cure ailments. The notion was that disease was caused by an imbalance in the body's "vital force" and that health could be restored via the regulation of the body's excretions and secretions. Pure (i.e., non-mineral) water would be drank and applied externally to the body via wet packs, ice packs, and sitz baths in order to restore health.[397] Mineral water took over as the method of water curing in the early Gilded Age. Thousand upon thousands of gallons of mineral water were sold to people or taken at mineral-water spas. Mineral water was the great diuretic and tonic; it could purify and enrich your blood, promote digestion, stimulate secretions, and vitalize your nervous system. As a curative, it could remedy aches, pains, constipation, piles (i.e., hemorrhoids), asthma, bronchitis, diseases of the skin, dyspepsia, diabetes, kidney and urinary tract infections, paralysis, and nervous prostration (i.e., stress).[398] The claim made by those peddling mineral water was that the minerals in the water were not present in public water supplies, and it was these minerals that were therapeutic.

Patent medicines were at their peak during the Gilded Age and the beginning of the twentieth century. Also known as potions or nostrums, patent medicines were concoctions, customarily stylishly bottled, that their fabricators made medical claims for. These compounds were of questionable effectiveness and their ingredients were often hazardous and dubious.[399]

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[396] McCoy, *Quack!*
[397] Armstrong and Armstrong, *American Medicine Show*, 80.
[398] Ibid.
[399] "Patent Medicine," Retrieved September 6, 2009 from http://en.wikipedia.org/wiki/Patent_medicine.

(Armstrong and Armstrong equate Gilded Age patent medicines with today's over-the-counter medicines that claim to cure anything from wrinkles to insomnia.) Patent medicines were commonly sold at traveling medicine shows and they could cure things like consumption, liver and bladder ailments, dyspepsia, and "female diseases."[400]

Magnetic gas-pipe therapy was a medical technique that incorporated the force of magnetism. The "electropoise" was an instrument that utilized the magnetic gas-pipe therapy; it was a metal pipe, closed at both ends, with a flexible wire attached, that one attached to one's body to get the desired cure. The "oxydonor" was another such instrument, shorter than the electropoise and also containing a stick of carbon inside the metal tube. Diaduction was the name of the force created by the electropoise and oxydonor, and apparently allowing this force to flow through one's body could cure diphtheria, whooping cough, and "most diseases in their first stage."[401] Bob McCoy, a twenty-first century medical historian, wrote of these devices, "In many ways this type of charlatanry is the worst, inasmuch as claims are made for it that are not only absurd, but dangerous."[402] McCoy is referring to the use of these types of devices on unwitting children, children whose diseases were curable with proper medical treatment, children whose diseases worsened because of the use of these devices.

Electricity was another force of nature that medical hoaxsters harnessed and sold to the public. *Dry cell batteries* sold in "battery boxes" were intended as a way to electrify the body by touching metal wires, connected to the battery, to the body. Battery boxes, or rather the application of electricity to the body, could supposedly cure a weak or lame back, cramps,

[400] Armstrong and Armstrong, *American Medicine Show*, 159.
[401] McCoy, *Quack!*, 46, 47.
[402] Armstrong and Armstrong, *American Medicine Show*, 46.

writers' cramp, cold feet, contracted muscles, nervous cough, poor circulation, general debility, headache, hysteria, neuralgia, palsy, paralysis, rheumatism, sciatica, and hair loss.[403]

The Actina pocket battery was another device that utilized electricity for medical cures. It was a chrome-finished cylinder that had copper ribbon spiraled outside of it, while inside was muslin soaked in sassafras, mustard oil, belladonna, ether, and amyl nitrate. The user would connect the circuit, and vapors would be emitted from the device, which were then inhaled by the user. The Actina pocket battery was purported to stimulate the blood vessels to remove congestion and improve circulation, cure eye diseases such as glaucoma, cataracts, and color blindness if applied to the eyes, cure deafness and ringing in the ears if applied to the ears, and cure cancer, angina, diabetes, gonorrhea, and tuberculosis if inhaled through the mouth and nose.[404]

Electric belts and headbands were belts with batteries on them which, when worn around the head or torso, were purported to radiate electricity to the whole body, electrifying the blood. The benefits of electrifying one's blood included alleviating restless nights, palpitations of the heart, loss of confidence, dizziness, fainting, loss of memory, melancholy, and liver, blood, and kidney disorders.[405]

Electric brushes were also popular during the Gilded Age; these were, as the name implies, hair or body brushes that were electrified one way or another (e.g., via batteries). Electric hair brushes were professed to prevent premature graying of the hair, stop hair loss, cure baldness, dandruff, scalp disease, headache, and neuralgia. Electric body brushes could improve one's complexion, cure constipation, rheumatism, and backache.[406]

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[403] McCoy, *Quack!*
[404] Ibid.
[405] Ibid.
[406] Ibid.

In the 1870s *colored glass* was believed to have healing rays when light was passed through the colored glass, blue glass in particular. Dr. James Walsh gave insight into this medical quackery in his 1924 book, *Cures That Fail*, laying bare the utter fraud of the devices. A glass making firm in the 1870s made an overabundance of blue glass that they needed to dispose of profitably. The blue glass was advertised as being helpful for all sorts of aches and pains, and when a Civil War general very publicly had success with the use of the blue glass, the public avidly took up the new cure. (Apparently the general's wounds would have healed just as effectively without the use of the glass, as he simply let them open to the air to heal.)[407]

As noted in the previous chapter on scientific hoaxery, the all-important question was how to combat against scientific and medical hoaxes. The simple answer given by scientists and science promoters was early scientific training; a scientific education, where students learned both the facts of science and how to think like a scientists, was an early remedy against medical hoaxery. The simple act of expressing doubt and asking for substantiating data when presented with a new medical claim was one way that thinking like a scientist would help against medical quackery.[408] Having the ability to detect poor (or pseudo-) science, or, in other words, to understand what is and what is not science was another aspect of a scientific education that was important here.[409] By teaching students something about the nature of science, they would be able to distinguish between real scientific facts and phenomena and false science because they would be given an understanding of what it takes to make a scientific claim and a scientific conclusion, how one goes about establishing a scientific fact, and the weight and value of a body of evidence.[410] Finally, knowing some of the facts of science would help against medical

[407] Ibid.
[408] Chamberlin, *Address*; and Cooke, "Nobility of Knowledge."
[409] Cooke, "Nobility of Knowledge."
[410] Ibid.; Chamberlin, *Address*; Fiske, *Edward Livingston Youmans*; and Mill, "Inaugural Address."

fraud.[411] For example, some elementary knowledge of the structure of the human eye might have been enough for people to disbelieve that vapors from sassafras and belladonna would cure color blindness. Because the arguments for teaching science in order to combat medical hoaxery were not substantially different from those for teaching science in order to combat scientific hoaxery, the main points have been laid out briefly here, and those interested in more details of these arguments should refer back to Chapter 4, “Scientific Fraud.” In fact, the Gilded Age discourse on teaching science to prevent hoaxery implied both scientific and medical hoaxery, and the separation of the two has been my own doing. I differentiated scientific and medical hoaxery in order to presented medical hoaxery in this chapter because medical hoaxes were a public health issue.

Doctors and Medicine

Medical education in America during the Gilded Age was only just beginning to achieve success and recognition. Throughout the nineteenth century many physicians were trained through apprenticeship rather than through medical schools.[412] Early medical schools had questionable standards, requiring only a high school diploma and an enrollment fee; they had “skimpy libraries, haphazard access to hospitals, and bare-bones clinical laboratories;” and they were sometimes called “diploma mills” by twentieth century historians.[413] Needless to say, medical school reform was an important topic during the Gilded Age. Although there was a good deal of Gilded Age discourse on the reforming of medical education, only that discourse which related to the inclusion of science in the secondary school curriculum is considered in this research.

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411 Brown, *Spectropia*; and Youmans, “Mental Discipline in Education.”
412 McCoy, *Quack!*
413 Armstrong and Armstrong, *American Medicine Show,* 3.

Thomas Henry Huxley was one such scholar who was concerned with reforming medical education as well as secondary school education. He was vexed with the caliber of students entering medical school. He felt that they were unprepared for serious study, and that they spent the first year of medical school "learning how to learn" rather than learning medical knowledge. Time spent learning how to learn meant that real medical school subjects like anatomy, physiology, therapeutics, medicine, surgery, and obstetrics had to be crammed into the final three years instead of using all four years of medical school to learn these things. He even went so far as to say that young men coming to the medical schools, "learn, for the first time, that there are such sciences as physics, chemistry, and physiology, and they are introduced to anatomy as a new thing."[414] Huxley's point, that medical students should learn some science before they enter medical school, may have been only a minor rationale in the greater argument to include science in the secondary school curriculum, but his discourse helped bring the topic of teaching science in the secondary schools to a larger audience, namely the medical field.

Although Charles Eliot was not a member of the medical profession, his preeminence as the president of Harvard University and as a champion of educational reform lent him credibility as a participant in the discourse on medical education reform. Eliot felt that the student going to medical school would have, in his school days, naturally been "drawn irresistibly to chemistry, physics, and natural history. He should have exhibited a natural tendency toward those subjects, and that tendency should have been gratified."[415] Eliot's argument indicates that he was less concerned with the caliber of students entering medical school than he was with the cultivation of inborn talents and preferences in students. His argument lent support to the drive to include science in the secondary school curricula, since the premise of his point was that science should

[414] *Science and Education*, 117, 251.
[415] *Educational Reform*, 277.

be taught to students early in their school careers so that those with natural aptitudes for medicine would be stimulated before they entered medical school.

Other prominent Gilded Age scientists and medical professionals also weighed in reforming medical education by teaching science to secondary school students. One of Thomas Henry Huxley's main suggestions for medical school reform was "to insist upon the teaching of the elements of the physical sciences in all schools."[416] Richard Quain, President of the Royal College of Surgeons, went even farther, writing, "Supposing that at school young people had acquired some exact elementary knowledge in physics, chemistry, and a branch of natural history – say botany – with the physiology connected with it, they would then have gained necessary knowledge, with some practice in inductive reasoning."[417] In other words, the way to allow medical schools to teach the necessary medical understanding was to assure that the basic facts of science had been taught elsewhere, prior to medical school. While this surely was an argument made more for the sake of medical schools than secondary schools, it was another effective argument for inclusion of science in secondary education. Although the purpose of these arguments was to have premed students to learn science early in their schooling, it helped the scholars' main argument for science in the secondary schools because all students would benefit; science would train the minds of all students and everyone would learn some facts and methods of science to help them in their everyday lives, regardless of whether medicine was going to be their profession or not. So, while this discourse was playing out in the higher education spheres, specifically in the sphere of medical education, their discourse and arguing points were beneficial to those scholars advocating for the inclusion of science in general education.

[416] *Science and Education*, 318.
[417] Quain, in Huxley, *Science and Education*, 116.

Whether or not students came to medical school with some knowledge of science, the social status of doctors in the Gilded Age was an issue that needed to be dealt with, since physicians did not enjoy high social esteem at this time in history. Thus the desire to raise the social standing of the medical profession was another aspect of the medical education discourse that aided scholars in their quest to have science taught in the secondary schools. Doctors were not highly regarded at the beginning of the Gilded Age, many people being of the opinion that doctors were "ill-trained [and] uninformed."[418] Many doctors had a shaky education and did not necessarily have formal credentials (either because they were trained via apprenticeship or because their medical school was simply a diploma mill). In the words of one Gilded Age scholar, "A majority of young medical practitioners were, therefore, uncultivated men, with scanty knowledge of medicine and surgery, who had had opportunity for but a small amount of observation by the bedside and but little practical experience in hospitals."[419] The poor education of physicians seems to have been an important reason, but only one reason among many, why they did not enjoy social prestige at this time.

Another reason why Gilded Age physicians were not highly socially regarded was because of their methods of medical treatment. Medical practices of the Gilded Age included bleeding (i.e., bloodletting), leeches, purgatives, and hot plasters to induce sweating and blistering.[420] Thomas Henry Huxley expressed the climate of fear surrounding medical treatment when he said:

> There is not one of us who may not at any moment be thrown, bound hand and foot by physical incapacity, into the hands of a medical practitioner. The chances of life and death for all and each of us, at any moment, depend on the skill with which that

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[418] Armstrong and Armstrong, *American Medicine Show*, 3.
[419] Eliot, *Educational Reform*, 345.
[420] Ibid.; and McCoy, *Quack!*

> practitioner is able to make out what is wrong in our bodily frames, and on his ability to apply the proper remedy to the defect.[421]

Armstrong and Armstrong, from their late-twentieth century perspective, put it aptly when they wrote, "in such a frightening climate, it is understandable why many feared and distrusted physicians."[422] Charles Eliot, addressing this fear and distrust of physicians, maintained that social power and standing for physicians would come with more education, as the public gave their confidence to educated men.[423]

The Gilded Age discourse on the social status and qualifications of physicians had a number of repercussions for the issue of teaching science in the secondary schools. Firstly, physicians themselves needed a better understanding of science, and as seen above, this would be best acquired before they entered medical school. A better understanding of science would, presumably, give physicians more credibility with their patients, as they could explain some of the science behind medicine and health to their patients. Secondly, patients needed a better understanding of science. By teaching science in the secondary schools, everyone would (theoretically) be familiar with the basics of science, and possibly science as relates to one's health; this would allow patients to understand what their physicians were saying to them, thus alleviating some of the fear and distrust people had of doctors. Thirdly, a scientific education for both physicians and patients alike (i.e., a basic science education in their secondary school years) could help everyone understand the difference between real and false medical claims.

Public Health as Relates to Scientific Literacy

As the preceding sections of this chapter have shown, the discourse seen in *CDML* was a product of the times, where issues of public health and sanitation, issues of medical quackery,

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[421] *Science and Education*, 115.
[422] *American Medicine Show,* 10.
[423] *Educational Reform*.

and issues concerning the medical profession led scholars to advocate for teaching science in the secondary schools. The analysis in the preceding sections of this chapter has also shown that the discourse found in *CDML* was being echoed in the larger intellectual arena. There was frequent public discourse on sanitation and public health and disease, with advances in epidemiology and disease theory changing our understanding of these issues during the Gilded Age.[424] There was also considerable discourse amongst scholars of higher education and medical education about improving the scientific education of physicians.[425]

The analysis of the preceding sections substantiates my claim that the discourse in *CDML*, by pulling together the ideas of a variety of scholars, framed a comprehensive view of science education for the first time in the history of education in the United States. As with previous chapters, the discourse in *CDML* is being treated as a representative sample of thought during the Gilded Age. Once again, I paid special attention to points that may have laid some foundations for our modern day notion of scientific literacy as I analyzed the discourse in *CDML*. By analyzing the discourse through a modern day lens of scientific literacy, I can gain greater insight into the discourse, a deeper analysis of it, and a way to organize my thinking about it. For an in-depth review of the current discourse on scientific literacy, please refer to Appendix A.

While I have explored three distinct threads of the Gilded Age discourse on public health, most of the scholars in *CDML* involved in one aspect of public health were also involved in other aspects of the issue. For example, George Paget, James Paget, and Edward Livingston Youmans were all keenly involved in both the discussions about health, disease, and sanitation and discussions about the medical profession. Furthermore, those scholars most enthusiastically

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[424] Fall, "Sanitary Science;" Peterson, "Sanitary Reform;" and Snow, "Cholera."
[425] Eliot, *Educational Reform*; and Huxley, *Science and Education*.

involved in these various issues of public health had some medical background. For example, Henry Acland was a medical professor, Richard Owen was an anatomist, George Paget was involved in the medical field, and James Paget was a surgeon and pathologist. Aspects of the arguments that these scholars put forth in terms of public health and science education have correlations with our modern day notions of scientific literacy. As with previous chapters, this discussion will be organized according to the nuances found in the modern day literature on scientific literacy.

Social Responsibility

In the modern day literature on scientific literacy the nuance of social responsibility has been defined with responsible and active citizenship in mind, where scientifically literate individuals are able to understand scientific issues read or heard in the media, able to discuss these issues knowledgeably, and, moreover, able to make informed democratic decisions about scientific issues.[426]

Most modern day scholars who advocate for scientific literacy from a social responsibility standpoint agree that scientific literacy includes being able to make informed decisions about scientific and technological issues that are in the national public agenda. In other words, scientific literacy involves using decision-making skills for scientific issues.[427] Part of being able to make informed decisions about scientific issues in the public agenda is being able to understand discussions of these things in the popular media.[428] While scientific issues in today's public agenda would include such things as acid rain, cancer, and nuclear power, these

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426 DeBoer, "Scientific Literacy;" Ewing et al., "Improving Student Attitudes;" Glynn and Muth, "Reading and Writing;" Hurd, "Scientific Literacy;" Koelsche, "Scientific Literacy;" Kolstoe, "Consensus Projects;" Lee and Roth, "Science and the 'Good Citizen';" Meehan, "Nuclear Safety;" Miller, "Scientific Literacy;" Oliver et al., "The Concept of Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.
427 Hurd, "Scientific Literacy;" Kolstoe, "Consensus Projects;" Lee and Roth, "Science and the 'Good Citizen';" Meehan, "Nuclear Safety;" Miller, "Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.
428 DeBoer, "Scientific Literacy;" Ewing et al., "Improving Student Attitudes;" Glynn and Muth, "Reading and Writing;" Koelsche, "Scientific Literacy;" and Oliver et al., "The Concept of Scientific Literacy."

were not what concerned Gilded Age scholars. In terms of public health, the dominant issues in the Gilded Age public agenda were disease and sanitation. By teaching students something about physiology and anatomy, thus aiding their acquisition of knowledge of health and disease, not to mention teaching them basic hygiene and sanitation, students would be responsible citizens who were scientifically literate about important scientific issues in the national public agenda.

The modern day scientifically literate individual is sometimes defined as someone who can not only understand what is printed or heard in the mass media but also be able to interpret it, make informed decisions about it, and form relevant, logical, and independent conclusions about it. Furthermore, being able to construct a good argument and understanding what it takes for others to construct convincing arguments is another science skill that plays a part in understanding scientific discourse in the mass media.[429] This modern day notion of scientific literacy is similar in spirit to what Gilded Age scholars felt the public must be able to do in order to combat medical hoaxery. Being able to think like a scientist, expressing doubt, demanding evidence, and ultimately making a decision about medical claims was a major aspect of combating medical hoaxery.[430] Take, for example, the following label for a patent medicine:

Zoagriaine

The Asthma Conqueror and Catarrh Cure

Purely Vegetable.

A Powerful

Blood Tonic,

An Active and Efficient

Alternative,

[429] Hurd, "Scientific Literacy;" Kolstoe, "Consensus Projects;" Lee and Roth, "Science and the 'Good Citizen';" Meehan, "Nuclear Safety;" Miller, "Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.
[430] Chamberlin, *Address*; and Cooke, "Nobility of Knowledge."

And an

Antispasmodic

Nervine.

Warranted a Specific and Reliable

Remedy for the Constitutional and

Permanent Cure of Asthma,

Catarrh and all Allied Diseases.

Free From Lobelia, Mercury and all

Deleterious Drugs.

It Cures Dyspepsia, Perfects

Nutrition, and Creates a New,

Healthy and Vigorous

Habit of Body.

Prepared only by

L.A. Smith, & Co. M. C.

New York, U.S.A.

None genuine unless bearing out

Fac-Simile Signature thus.[431]

By using the thought processes of scientific inquiry, one would question what the ingredients are and how the medicine can permanently cure asthma. The scientifically literate individual, both currently and in the Gilded Age, would also be able to interpret that this is a drug-free tonic. Finally, the scientifically literate individual would be able to make their own logical and independent opinion of this product.

[431] McCoy, *Quack!*, 8.

According to various present-day scholars of scientific literacy, "informed skepticism," or being able to evaluate and make critical judgments about science and scientific authority is another facet of the scientifically literate individual.[432] For example, a scientifically literate person would be able to distinguish between scientific and pseudo-scientific questions. According to *SFAA*, this means being able to combat "dogmatists, flimflam artists, and purveyors of simple solutions to complex problems."[433] The Gilded Age discourse about medical hoaxery is comparable in character. A scientifically literate individual of the Gilded Age would, like their modern day counterpart, have the ability to distinguish between science and pseudo-science.[434] As with scientific hoaxery, knowing what it means to call something a law of nature, understanding what kinds of evidence and reasoning it takes to make a scientific conclusion, and understanding what it takes for others to construct convincing arguments would have all been important things for a scientifically literate person to know in order to make informed decisions about medical hoaxes.[435] One outcome of the Gilded Age fight against medical hoaxery would be scientifically literate individuals who were informed skeptics about purported medical remedies.

For some modern day scholars of scientific literacy, the ability to make critical judgments about scientific authority involves knowing when to seek expert advice and where to find access to responsible expert advice.[436] The Gilded Age scholars involved in discourse about reforming medical education struck a similar tone in some of their points. Scholars like James Paget and Edward Livingston Youmans felt that by teaching students some science in school (particularly

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[432] AAAS, *SFAA*, 186; Kolstoe, "Consensus Projects;" McGinn and Roth, "Preparing Students;" and Shamos, *The Myth of Scientific Literacy*.
[433] AAAS, *SFAA*, xiv.
[434] Cooke, "Nobility of Knowledge."
[435] Ibid.; Chamberlin, *Address*; and Fiske, *Edward Livingston Youmans.*
[436] DeBoer, "Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.

physiology and natural science), they would be more knowledgeable about their health and when it was necessary or unnecessary to seek medical advice or treatment.[437] Scientifically literate patients would also be able to understand the things their scientifically literate physicians told them, thus improving medical care for both patients and doctors alike.[438]

Interaction of Science and Society

The interface of science and society is another common thread of discourse on scientific literacy in the modern day literature. Morris Shamos calls this “science-based societal issues.”[439] The standard argument given for promoting scientific literacy here is for students to be aware of, and be able to respond to, societal impacts of science.[440] The important aspect of this in the Gilded Age would have been the capacity to respond to societal impacts of science, specifically health, hygiene, sanitation, and disease. In fact, Gilded Age scholars were advocating for a form of scientific literacy where the public would be able to deal with societal impacts of science in terms of their own health and wellbeing and in terms of advances made in sanitary science and disease theory. The point was made earlier that the teaching of health and hygiene was utilitarian in nature, and that it did not explicitly fulfill the purpose of education to train the mind. This point is valid, but we can see here that teaching students about health, sanitation, hygiene, and disease *was*, in fact, creating scientifically literate students who were able to respond to these societal impacts of science.

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[437] Paget, J., “Study of Physiology;” and Youmans, “Mental Discipline in Education.”

[438] Hooker, “Extracts;” and Paget, G., “Influence of Scientific Culture.”

[439] Shamos, *The Myth of Scientific Literacy*, 77.

[440] Bybee, “Achieving Scientific Literacy;” Culliton, “Dismal State;” Evans, “Scientific Literacy;” Ewing et al., “Improving Student Attitudes;” Hofstein and Yager, “Societal Issues;” Miller, “Scientific Literacy;” and Mitman, Mergendoller, Marchman, and Packer, “Components of Scientific Literacy.”

Organization of Knowledge

Modern day scholars consider the organization of knowledge one aspect of scientific literacy. They partly define the organization of knowledge as knowledge and understanding of the basic facts, principles, and vocabulary of science.[441] In terms of the Gilded Age and the issues explored in this chapter, a knowledge and understanding of basic scientific facts and principles such as the structure of the eye, the transmission of contagions, and the anatomy of the respiratory system, coupled with a knowledge and understanding of the basic vocabulary of science such as tissue, vein, bone, and respiration would have been important things for the scientifically literate person to have.

Knowledge and understanding of the examples given above would help in all three aspects of public health discussed in this chapter. Knowledge of basic anatomy and physiology would help address health and disease problems; this same knowledge would also help address the problem with students coming to medical school unprepared in science; the same knowledge would help patients be able to communicate with their doctors; and the same knowledge would help people to better understand and thus combat medical hoaxes. While the scholars in *CDML* may not have been explicit about scientific literacy in their discourse, they certainly advocated for teaching students the facts and principles of science, or the organization of scientific knowledge, as a way to address public health concerns.

Conclusion

To review, the main arguments examined in this chapter all addressed issues of public health in one way or another. Scientists who were concerned about health and disease prevention advocated for the teaching science in order to promote health and prevent disease. Subjects such as physiology, biology, and later hygiene (although not necessarily a science itself) could

[441] AAAS, *Benchmarks*, *SFAA*; Koelsche, "Scientific Literacy;" and NRC, *Standards.*

achieve their needs, needs which were necessitated by the unsanitary conditions of Gilded Age life and by the devastating death toll from diseases like consumption, pneumonia, and diphtheria. Other scientists considered in this chapter were concerned with medical quackery. Similarly to the issues surrounding scientific hoaxery presented in the previous chapter, the scholars considered here advocated for teaching science so that people would be able to think like scientists, detect false science, and not be taken in by medical hoaxes. Unlike the scientific hoaxes presented in the previous chapter, those scholars concerned with medical hoaxery were more alarmed by pseudo-science because in the case of medical quackery people's health and even lives were at issue. Finally, other Gilded Age scholars examined in this chapter were concerned with conditions in the medical field. This was a time when reputable medical schools were only beginning to prevail, and some Gilded Age scientists argued that teaching science in the secondary schools would better prepare students for medical college. Some scholars examined in this chapter were concerned with the social standing of physicians, and they argued that a better understanding of science (via a scientific education in secondary school as well as better science in medical school) would gain physicians more respect from their patients. Along these same lines, patients would be more likely to respect their physicians and their physicians' knowledge if the patients themselves had some basic knowledge and understanding of science.

Improving the health and sanitary conditions of people in the Gilded Age (through their understanding of health, hygiene, and disease; through the improved education of physicians; and through the impeding of medical hoaxery) was an important social issue. While this chapter has explored how teaching science in the schools was the answer to improving Gilded Age health and sanitary conditions, education was not the sole answer to these problems. The progress of science and medicine and technology was another facet of improving people's lives, both their health and their lives in general. The progress of science itself was a minor but significant issue that some Gilded Age scholars turned their attention and arguments toward, and it is to this topic that we now turn.

In this century three scientists have revolutionized commerce – Oersted, of Copenhagen, and Faraday and Wheatstone, of London. It was of Faraday that Huxley said, in effect, that any nation would do well to spend $500,000 in discovering such a man, and an equal amount in educating and setting him to work.

"Scientific Progress"

CHAPTER 6

SCIENTIFIC PROGRESS

Introduction

This chapter will be presented in a manner similar to the previous chapters, where the discourse in *CDML* is used as a foundation for the analysis of discourse around a specific science education issue. This discourse will then be examined and analyzed utilizing other Gilded Age literature and various secondary sources from both the twentieth and twenty-first centuries. As such, in the first section of the chapter the arguments found in *CDML* will be laid out as they appear in that book, with discussion and elaboration being saved for the second section of the chapter. Finally, in the third section of the chapter the Gilded Age discourse will be examined through the lens of our modern day notions of scientific literacy.

In this chapter I explore those arguments for science education that relate to the progress of science itself. The Gilded Age scholars investigated in this chapter were concerned about keeping scientific and technological progress occurring apace. Teaching students science in the secondary schools was a way to train and education those students who would pursue scientific careers, and it was also a way to educate everyone else about science with the goal of instilling a sense of enthusiasm for scientific progress. Included in the second section of the chapter are explorations into the nation's infatuation with Progress during the Gilded Age as well as certain nationalistic tendencies seen in the literature as relates to scientific progress and science education.

Scientific Progress as Seen in *Culture Demanded by Modern Life*

The fundamental argument that will be explored in this chapter was that science needed to be taught in the secondary schools for the sake of scientific progress. The rationale was both about teaching students science so that future scientists could be identified and prepared for scientific work and about instilling a sense of respect for science. This respect was thought to create support for scientific endeavors in those students who would not become scientists. Nearly one third of the scholars found in *CDML* had something to say on this topic, but many of them simply praised scientific progress or asserted how important scientific progress was to our everyday lives and the wealth and power of our nation. This kind of rhetoric, because it is found in a book devoted to the cause of including science in the secondary school curriculum, implied that science learning in the secondary schools was linked to scientific progress. For their part, William Carpenter and James Paget made the explicit argument that teaching science was a crucial part of greater scientific progress. Although quite a few scholars had something to say about scientific progress, the argument being examined in this chapter, to teach science in the secondary schools for the sake of scientific progress, was only a very minor rationale in the greater argument to include science in the secondary school curriculum.

Individuals living through the Gilded Age were often astonished by the progress of science. The term science was often used in a loose way, as a synonym for science, applied science, technology, and general progress. (Please see the section on science and technology in Chapter 3 for a more detailed discussion of this point.) Great things were attributed to science, and there was, for many people, a reverence for the might of science. Prince Albert, the husband of Queen Victoria, had adopted the cause of educational reform in his lifetime. Writing of the might of science, Prince Albert said that it “had altered our whole state of existence – one might say, the whole face of the globe. We own this to science, and to science alone.”[442] Thomas Henry Huxley was likewise reverential about science, writing that “the whole of modern thought is steeped in science,” and that “modern civilization rests upon science.”[443] Arthur Henfrey went one step further, writing that the civilization of the human race depends upon science.[444] While it might seem biased and slightly obvious to state that scientists praised science in their discourse, it will be shown in the second section of this chapter, where I examine other literature form the Gilded Age, that many people felt the same way as scientists about the power of science.

Some of the scientists in *CDML* also praised science for making their nation great. John Tyndall described Great Britain “as a land of gas and furnaces, of steam and electricity: as a land which science, practically applied, has made great in peace and mighty in war.”[445] Thomas Henry Huxley felt much the same when we wrote that the position of Great Britain among the leading nations of the world would be gone tomorrow if the gift of science were taken away.[446] In other words, the great might, both militarily and otherwise, of the world’s great nations was founded on the power of science. This sentiment alone would have been reason enough to teach science in the schools – the leading nations of the world (i.e., America and Great Britain) needed

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[442] “Educational Claims of Science,” 444.
[443] “Study of Zoology,” 144.
[444] “Study of Botany.”
[445] “Study of Physics.”
[446] “Study of Zoology.”

to *stay* the leading nations of the world by ensuring that knowledge and application of science keep them in front.

The Gilded Age belief in the power of science sometimes manifested itself in the idea that man had the God-given right to conquer nature and obtain its powers.[447] In fact, some scientists felt that man was essentially assured of harnessing the forces of nature, that is when man was wise enough to command them.[448] If men had the right to conquer nature and direct its powers, then men must know enough science to do so. The rationalization for including science in the secondary school curriculum that followed from these sentiments stated that we needed to teach science to our students so that we could teach the next generation to utilize the forces of nature.

Much of the rhetoric on this topic revolved around the notion of progress, in a typically liberal manner. (Please see the section in Chapter 2 where I discuss the topic of liberal and conservative rhetoric in the Gilded Age for a better understanding of this topic.) According to Edward Livingston Youmans, progress was the guiding principle of science.[449] Coming from a liberal standpoint, Youmans made this point as a way to say that the classics are forever looking backward while science is forever looking and moving forward. Also employing liberal rhetoric, William Hodgson said that humankind itself was progressive, the heirs of past discoveries, inventions, thoughts, and labors.[450] The implication here was that the progress of science was a positive and necessary influence on the progress of mankind. Justus von Leibig, a Gilded Age chemist and one of the only continental Europeans whose discourse is found in *CDML*, made a point similar to Hodgson's about progress. Von Leibig placed great importance of the continued

[447] Henfrey, "Study of Botany."
[448] Tyndall, "Study of Physics."
[449] "Mental Discipline in Education."
[450] "Study of Economic Science."

progress of both science and civilization and said that humankind must be ready for scientific progress.[451] To these Gilded Age scientists, the progress of science was immensely important on its own, but this was coupled with the notion that the progress of science was crucial for the progress of mankind. This dual argument was a very powerful statement for teaching science in the schools because contributing to the progress of mankind was a formidable position to be in.

Progress was so thoroughly important of a topic that Edward Livingston Youmans' first statement to the reader made this point. He began the *CDML* with the following liberal phrase: "All educational inquiries assume that man is individually improvable, and therefore collectively progressive."[452] Youmans' purpose for publishing *CDML* was to collect together arguments for teaching science in the schools, and it is telling that the very first statement in the book is of progress. He sets the stage for the entire book by identifying progress as the leading characteristic of educational reform.

The fundamental argument that is being considered in this chapter was that science ought to be taught in the schools for the sake of the progress of science. In other words, the scholars in *CDML* maintained that we must find the students best fitted for the study of science and prepare them to become future scientists. Both James Paget and William Carpenter wanted to introduce students to science early so that those with a natural aptitude for it would be introduced to science before college.[453] By finding those students best suited for scientific study, Gilded Age scientists felt that we would be generating future scientists who would ensure that the progress of both science (and by extension mankind) would occur apace.

One final argument made in *CDML* for teaching science for the sake of scientific progress was tied to the Gilded Age notion that scientific progress was linear and accumulative.

[451] "Development of Scientific Ideas."
[452] "Mental Discipline in Education," 1.
[453] Paget, J., "Study of Physiology;" and Carpenter, "Extracts."

Justus von Liebig held this opinion and expressed it by writing, "scientific progress depends on the accumulation of facts."[454] William Whewell also felt that scientific knowledge was linear and cumulative, writing that we are "the inheritors of the wealth of all the richest times."[455] In other words, generations successively built upon the knowledge of their forbears. From the words of these scholars, it appears that Gilded Age scientists held on to the belief of the linear and accumulative nature of scientific discovery and knowledge. Today, with the work of Thomas Kuhn to guide our thinking about the growth of scientific knowledge, we would be more apt to say that science is not linear, rather that progress occurs via revolutions.[456] With that said, the Gilded Age scientists cited here felt that by teaching science to students, they would learn the science that would later be built on. One example of this was in the science of physiology. Physiology was a relatively new scientific discipline in the Gilded Age and much was still to be learned and discovered, particularly about human physiology and the corollaries of health, sanitation, and disease. James Paget was well aware of this fact and advocated for the teaching of physiology so that progress would occur quicker in that science.[457]

In conclusion, teaching science for the sake of scientific progress was by no means the most important argument found in *CDML*, and only a handful of the scholars made a point to discuss it. With that said, the progress of science, of education, and of mankind itself was such a crucial part of Gilded Age thinking that this argument held some considerable weight.

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[454] "Development of Scientific Ideas," 352.
[455] "Educational History of Science," 229.
[456] Kuhn, *Structure of Scientific Revolutions.*
[457] "Study of Physiology."

Scientific Progress as seen in Other Literature

The Cult of Progress

Gilded Age discourse was replete with discourse about Progress. The Reverend John Gregory, writing in the 1880s, said that the nineteenth century "has frequently been called the century of progress. There is a fever for progress."[458] John Fiske, in his turn of the century book entitled *A Century of Science*, felt that "the world is in a process of development."[459] Fiske's underlying assumption was that progress and development were good, essential, and enlightened features of society. John Sproat, a mid-twentieth century historian of the Gilded Age, explained why there was so much discourse about progress during the Gilded Age. He wrote that there was a "national infatuation with progress…Who in America could reject the future or deny the inevitability of national greatness?"[460] Giving further enlightenment on the point, Arthur Alphonse Ekirch, Jr., an historian writing in the middle of the twentieth century, wrote that "The idea of progress is one of those vague concepts which have been cherished, at least until recently, by a large portion of the modern Occidental world."[461] Ekirch contended that one of the underlying tenets of the cult of progress was that the progress of society and the progress of individuals were the two circumstances necessary for the existence of civilization. Furthermore, in nineteenth century America and Britain the idea of progress was removed from the exclusive domain of philosophers to become a part of the ideology of the public.[462] Because the notion of progress had been popularized and made accessible to all levels of thinkers, there was, for many individuals living in the last decades of the Gilded Age, an idolization of progress.

[458] Gregory, *The Sciences and Arts*, 4.
[459] *Century of Science*, 36.
[460] Sproat, *Best Men*, 5.
[461] *Idea of Progress,* 7.
[462] Ibid.

Arthur Ekirch used the context of the industrial revolution and the notion of progress to address the larger point of how progress was related to American society. He wrote that the industrial revolution gave a "material reality to the dogma of progress," and that "to the generality of the American people it was the practical application of the powers of science that furnished the most obvious evidence of progress."[463] John Gregory, the first president of the University of Illinois, confirmed Ekirch's theory when he said, "We must penetrate the progress to discover the power which produces and guides it. Thus looking and thus penetrating, we reach the secret. It stands revealed in the one word – SCIENCE."[464] In other words, people felt that science was singularly responsible for progress. It is important to note that Gregory was *not* a scientist; he was a Gilded Age Baptist clergyman, educator, and advocate of the classical curriculum. In the first section of this chapter the point was made that, as might be expected, scientists would feel that science was a crucial aspect of progress. As Gregory shows, and as John Sproat and Arthur Ekirch verify, much of the population, not just scientists, felt that science was a crucial part of progress.

These facts are important in the discussion about science education – the cult of progress was pervasive, and science was the material face of progress. The combination of these two realities made an easy rationale for those advocating for the teaching of science in the schools, a point that Carl Kaestle, in his modern day educational history, was aware of. He wrote, "Images of progress pervaded the school reformers' argument. That made it hard for their opponents. It is difficult to be against progress."[465] Thomas Henry Huxley put an exclamation to this point when he wrote, "The diffusion of thorough scientific education is an absolutely essential condition of

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[463] Ibid., 16, 106.
[464] *Sciences and Arts*, 5.
[465] *Pillars of the Republic*, 218.

industrial progress."[466] Using even more commanding rhetoric, James Dana, a Gilded Age scientist, felt that progress in science was "demanded as our bounden duty."[467] Dana's line of reasoning, that scientific progress was mankind's destiny, was hard to challenge. In fact, as noted in the previous section of this chapter, by taking the stance of being the champions of progress, the scientists made a formidable place for themselves in educational reform.

As noted above, the application of science provided a material face for the cult of progress. It may be illuminating to survey some of the science and technology of the Gilded Age to demonstrate the validity of this notion. It certainly seems that Gilded Age scholars felt they were in the midst of some pretty amazing times. John Gregory claimed that "science like light liberates, and the science of this century has liberated the powers of man from the thralldom which made progress slow and toilsome."[468] Fernando Sanford, the first professor of physics at Stanford University, wrote that mankind had made greater scientific progress in the nineteenth century than in the entire previous history of man upon the earth.[469] Reverend John P. Newman, a Gilded Age clergyman and scholar, was likewise of the opinion that the Gilded Age was a time of amazing scientific progress. He felt that science had transformed the ocean and the earth, and that if science could accomplish so many things (e.g., the railroad, steamship, electric telegraph, photography, gas lights, chlorine bleaching, anesthesia, sewage disinfecting, and sugar refining) in the past two-hundred and fifty years, the future was auspicious.[470] Karl Pearson, a Gilded Age polymath, put scientific progress into perspective when he wrote, "It is very difficult for us who live in the last years of the nineteenth century to rightly measure the relative importance of what

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[466] *Science and Education*, 139.
[467] *Science and Scientific Schools*, 17.
[468] *Sciences and Arts*, 5.
[469] *Scientific Method*.
[470] *Beneficence of Science*.

our age is doing in the history of civilization."[471] With that said, Pearson's underlying assumption was that the last decades of the nineteenth century would prove to be of crucial importance to the history of mankind. Furthermore, Gilded Age scholars did, in fact, believe that they were living through auspicious times for scientific progress.

The Progress of Science and Science Education

The notion of progress, particularly scientific progress, was so all-important in Gilded Age ideology that those advocating for the teaching of science used it as an element to promote the evolution of their argument. The most basic argument was that science ought to be taught in the schools in order to identify and prepare future scientists. Edward Livingston Youmans, in a book he wrote entitled *Handbook of Household Science,* which was a book of the practical applications of chemistry, certainly saw the value in finding students suited to scientific careers. He put it as follows: "An important result of the more earnest and general pursuit of science by the young will be to find out and develop a larger number of minds having natural aptitudes for research and investigation."[472] Charles William Eliot felt much the same as Youmans. In his role as the president of Harvard University, Eliot was an early advocate for the elective system of school subjects (as opposed to a single prescribed curriculum for all students), writing that choice in studies would develop students' natural preferences and inborn aptitudes.[473] While not exclusively addressing the teaching of science, Eliot's point was advantageous for science education, as an early education in science could help teachers and scientists identify those students who had natural aptitudes for science. Thomas Henry Huxley also saw the value of giving children possessing high natural ability in science a helping hand. He wrote, "But is it not worse economy to prevent a possible Watt from being anything but a stoker, or to give a possible

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[471] *Grammar of Science*, 2-3.
[472] Youmans, as cited in Fiske, *Edward Livingston Youmans*, 99.
[473] *Inaugural Address*.

Faraday no chance of doing anything but to bind books. Indeed, the loss in such cases of mistaken vocation has no measure; it is absolutely infinite and irreparable."[474] Huxley was implying here that by teaching science to all students in the secondary schools, those students with innate talents in science would be encouraged and educated. Those who were the most gifted as potential scientists would be identified, eventually becoming scientists and participating in the progress of science.

Being able to identify those students who could be future scientists was an important part of science education for the progress of science, but it was not the only part. By teaching science in the schools, future scientists would be learning the foundations of their field. Thomas Henry Huxley gave a good example of this argument, writing of a particular engineer friend of his who lost much time after leaving secondary school because "he had to devote himself to pursuits which were absolutely novel and strange, and of which he had not obtained the remotest conception from his instructors. He had to familiarize himself with ideas of the course and powers of Nature, to which his attention had never been directed during his school-life."[475] The obvious lesson here was that this engineer should have learned some science in his school days so that he did not waste time outside of school learning things he could have learned while in school. Edward Everett, the first American to receive a Ph.D. degree, made a point similar to Huxley's. He said that many scientists in the past had wasted valuable time pursuing discoveries or inventions that did not come to fruition because they lacked a better acquaintance with those scientific principles which would have taught them that their work would not succeed.[476] It would, of course, have been better had these scientists known more of the principles of science so that they had not wasted their time, and the clear lesson here was that we should teach our

[474] Huxley, *Science and Education*, 400.
[475] *Science and Education*, 114-115.
[476] Everett, *Practical Education*.

future scientists this scientific knowledge in secondary school before they waste their time after leaving school. The fundamental point being made by both Huxley and Everett was that if merely the general laws and principles of science were taught, it would greatly multiply the number of individuals competent in the field of science.

Gilded Age scholars also saw beyond the need to give future scientists some of the foundational scientific knowledge they would need in their future professions - future scientists also needed to learn something about the collective nature of science. Josiah Cooke, America's first Nobel laureate in chemistry, reminded the readers of the "Popular Science Monthly," Edward Livingston's magazine publishing articles about science for the general reader, that scientific invention is never the work of any single man, rather it is the result of growth of knowledge and the work of many men.[477] The implications of this notion for science education and the progress of science was that teaching our future scientists lessons like teamwork and diligence would presumably help science to progress more quickly and more smoothly.

In terms of teaching our future scientists science in the secondary schools, William Whewell saw the value of teaching them something about the history of science, which is not surprising since Whewell himself was an historian of science. His opinion was that by teaching students (i.e., future scientists) the history of science they would be able to learn from the mistakes of the past, the scientific controversies of the past, and base their "modes of discovering truth" on the truths that had been discovered in the past.[478] Learning something of the nature of science, as advocated for by Josiah Cooke as mentioned above, and learning something about the history of science, as advocated for by Whewell, were felt to be just as valuable as learning some

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[477] "Nobility of Knowledge."
[478] "Educational History of Science," 229.

of the facts and principles of science when it came to teaching science for the sake of scientific progress.

There was an interesting thread in the literature I have reviewed for this research that dealt with the fact that prior to the Gilded Age most scientists were self-taught. In fact, Edward Everett revealed one anti-science teaching argument that stemmed from this fact. Apparently science education naysayers argued that if most of the greatest discoveries and inventions of the past were the product of self-educated men or accident, why teach science at all – science will progress on its own, as it had in the past. Everett's ready answer to this was that yes, it may have been true in the past that accident and self-education were agents of scientific progress, but that was because science education did not exist.[479] The point here was that scientific progress could occur more rapidly if mankind did not have to wait for accidents.

Thomas Henry Huxley was concerned about the time self-educated scientists wasted in having to teach themselves science. He wrote that self-taught scientists "are not trained in the courts of the Temple of Science, but storm the walls of that edifice in all sorts of irregular ways, and with much loss of time and power, in order to obtain their legitimate positions."[480] Huxley, like Edward Everett, understood that many of the greatest scientific discoveries had come to self-taught men. His point in writing what he did was to assert, like Everett, that the progress of science could occur quicker if these men were educated in science, as they would not lose as much time and power teaching themselves.

Included in this thread of the self-education of many of the greatest scientists, there was also this notion that many past scientists were geniuses. Gilded Age scholars and scientists who saw self-educated men discover great scientific truths came to the conclusion that these men

[479] *Practical Education*.
[480] *Science and Education*, 105.

must have been rare and exceptional geniuses. Charles Eliot, in his inaugural address as the president of Harvard University, perpetuated this notion that self-educated men were geniuses. He said:

> Mediocrity is the unattractive average of the race; though its capabilities, wisely stimulated, and diligently cultivated, constitute the working forces of the world. Genius, with its brilliant but often erratic efforts, is the rare exception on human endowment. The former needs all the fostering and patient care the teacher can bestow. The latter is self-reliant and sufficient unto itself.[481]

Eliot's point here was that most of mankind are *not* geniuses, that most students' intellect needs careful cultivation, and that geniuses will teach themselves whatever they need to know with or without guidance. Actually, Eliot's statement seems to be exactly what Edward Everett was referring to when he said that science naysayers would claim that science education is pointless if scientific geniuses can carry out their work without formal scientific education. Eliot, it should be said, was *not* a science naysayer; if fact, it has already been pointed out that he was an advocate for science education. My point here is simply that Eliot was perpetuating (possibly unconsciously) the unhelpful notion that scientific geniuses will come along, teach themselves, and live out their destinies without the help of ordinary men or formal scientific training. The success of self-educated scientists was an unhelpful notion for educational reformers because it implied that formal science teaching was unnecessary. For their part, the scientists capitalized on the public's infatuation with progress to counter this unhelpful notion, saying that if we wanted science to progress apace, we must train up ordinary men to make up for the inherent lack of geniuses. In other words, schooling needed to *create* future scientists so that it was not just sitting back waiting for the next genius to come along and hand us some scientific truth.

[481] *Inaugural Address*, 21.

The finding and educating of future scientists was the most significant aspect of the argument that promoted the teaching of science in order for science to progress. The problem with an argument like this was that it was somewhat elitist, in that the beneficiaries here were only those students who were likely to become scientists. While the Gilded Age scholars did not acknowledge this point in the discourse, there were some concessions made to the rest of the students who did not intended to become scientists, and this came in the form of enthusiasm for science.

Kim Tolley, a late twentieth century historian, pointed out that, "In an era when few public funds were available for scientific enterprises, the popularization of science ensured a public receptive to the necessary financing of experiments, surveys, and expeditions."[482] Tolley's point seems reasonable, and confirmation of it can be seen in the Gilded Age literature I have examined. Edward Livingston Youmans felt that the progress of science would be hastened most significantly by kindling an enthusiasm for science in the minds of the young.[483] John Gregory felt the same, saying that educating students in science would help with the progress of science because it would provide an "appreciate and applauding population" that would cause scientists to work "with a double zeal."[484] In other words, the enthusiasm of the public for science would spur on the scientists to work harder, thus helping science to progress.

In a more unusual and xenophobic line of reasoning, some Gilded Age scholars argued for the teaching of science so that *American* science could progress. The basic argument here was that science needed to be taught in the schools so that Americans could invent things, make scientific discoveries, and participate in scientific progress, thus ensuring America's national greatness and influence. In fact, Josiah Cooke, an American chemist, claimed that our national

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[482] "Science for Ladies," 152.
[483] Fiske, *Edward Livingston Youmans*.
[484] *Sciences and Arts*, 10.

greatness and influence was of the utmost importance to the welfare of American society.[485] In another example, a New York Times article from 1868 stated that Louis Agassiz, an influential scientist in America, urged for the teaching of science "for the honor and renown of America, in order that we may take the foremost rank in the scientific world."[486] This is truly an interesting statement, since Agassiz was actually Swiss-born and educated. Evidently having spent the last nearly three decades of his life living and working in the United States gave Agassiz some authority to speak on such a topic. In one final example of the nationalist rhetoric related to scientific progress, Daniel Coit Gilman wrote that one of the values of science education was promoting scientific research for the development of our natural resources, since the public wanted an education that would help in the material advancement of mankind.[487] While this was not necessarily a xenophobic statement, it was laced with nationalistic undertones, where the welfare of America was the most important consideration.

Scientific Progress as Relates to Scientific Literacy

As the preceding sections of this chapter have shown, the discourse seen in *CDML* was a product of the times in which it was published. In those times, the progress of science and civilization was a national obsession of which scholars took advantage to advocate for teaching science in the secondary schools, maintaining that scientific progress would occur apace if students were taught science in the secondary schools. The analysis in the preceding sections of this chapter has also shown that the discourse found in *CDML* was being echoed in the larger intellectual arena. Historians like Arthur Ekirch pointed to the national infatuation with all things that even hinted at progress. Much of the literature from the Gilded Age does, in fact, show admiration for science and progress. Furthermore, influential educational reformers like Charles

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[485] "Nobility of Knowledge."
[486] "Science in America," 5.
[487] "National Schools of Science."

Eliot, Edward Everett, and Prince Albert advocated for teaching science for the sake of scientific progress.

As noted in the previous chapters, my claim that the discourse in *CDML*, by pulling together the ideas of a variety of scholars, framed a comprehensive view of science education for the first time in the history of education in the United States, has been substantiated by the analysis presented in this chapter. As such, the discourse in *CDML* is being treated as a representative sample of thought during the Gilded Age. Furthermore, following my rationalization in the previous four chapters, I have paid special attention to points that may have laid some foundations for our modern day notion of scientific literacy as I analyzed the discourse in *CDML*. By analyzing the discourse through a modern day lens of scientific literacy, I can gain greater insight into the discourse, a deeper analysis of it, and a way to organize my thinking about it. For an in-depth review of the current discourse on scientific literacy, please refer to Appendix A.

Admittedly the Gilded Age argument to teach science in order for science itself to progress was only a minor argument found in *CDML*. However, as my analysis above has shown, it was a powerful argument because of the public's obsession with progress in general and scientific progress in particular. While almost a third of the scholars found in *CDML* made some mention of this topic, none focused their entire discourse on it. With that said, the discourse that has been examined in this chapter does have implications for scientific literacy and shows parallels with our modern day notion of scientific literacy. As with previous chapters, this discussion will be organized according to the nuances found in the modern day literature on scientific literacy.

Social Responsibility

Present day scholars of scientific literacy have defined scientific literacy for social responsibility as using a scientific habit of mind to be a responsible and active citizen. The scientifically literate citizen should be able to understand scientific issues they read in the media, discuss these issues knowledgeably, and, moreover, make informed democratic decisions about scientific issues. Here, an understanding of the concepts and principles of science is less important than decision-making skills and the ability to participate in a democracy where scientific issues arise.[488]

The Gilded Age discourse on teaching science for the sake of scientific progress may, at first, not seemingly have implications for scientific literacy, particularly for the social responsibility issues that modern day scholars see as a fundamental part of scientific literacy. However, while the Gilded Age scholars in *CDML* did not specifically refer to scientific literacy issues in their discourse about science education and the progress of science, we can perceive some scientific literacy implications from their arguments.

In truth, social responsibility aspects of scientific literacy would not have applied to those students who were going to be future scientists. Rather, scientific literacy for social responsibility would have applied to all other students learning science, namely those students who were not going to become scientists but rather become consumers of science. As noted above, during the Gilded Age it became important for the general public to develop an enthusiasm for science and the desire to support scientists and their work. Support for science was of paramount importance if science were to progress, and there are scientific literacy implications that can be interpreted from these points. The scientifically literate general public

[488] DeBoer, "Scientific Literacy;" Ewing et al., "Improving Student Attitudes;" Glynn and Muth, "Reading and Writing;" Koelsche, "Scientific Literacy;" and Oliver et al., "The Concept of Scientific Literacy."

would be able to make decisions about scientific issues in the public agenda, in this case particularly those scientific issues that may have required public funding and support. The scientifically literate public would also be able to understand discussion of scientific issues in the popular media, interpret the discourse, and make critical judgments about the issues if necessary.

Consider this example. In the period immediately following the U.S. Civil war, geologists were still unsure about the composition of the earth and the solidity (or liquidity) of its core. Chemical and geological research was underway to determine these things, and this research required financial support. While this scientific issue was not necessarily one for which a highly consequential impact on the common man was then evident, it was an important step forward in the progress of science. The scientists could see forward to a time when the products of their research would profoundly impact the societies of the nations. And thus the scientists needed a scientifically literate public to support them and their research.

Interaction of Science and Society

In terms of the interaction of science and society, the standard argument given for promoting scientific literacy in the modern day literature is for students to be aware of, and be able to respond to, societal impacts of science.[489] The fundamental assumption of scholars who advocate for scientific literacy as a way to navigate the interactions of science and society is based in the idea that science is socially situated.[490] Several modern day scholars of scientific literacy stress the social nature of science. For example, Annemarie Palincsar, Charles Anderson, and Yvonne David use collaborative problem solving in a middle school classroom to promote scientific literacy, with the notion that science itself is a collaborative, social activity where

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[489] Bybee, "Achieving Scientific Literacy;" Culliton, "Dismal State;" Evans, "Scientific Literacy;" Ewing et al., "Improving Student Attitudes;" Hofstein and Yager, "Societal Issues;" Miller, "Scientific Literacy;" and Mitman, Mergendoller, Marchman, and Packer, "Components of Scientific Literacy."

[490] Lee and Roth, "Science and the 'Good Citizen';" McGinn and Roth, "Preparing Students;" Roth, "Scientific Literacy;" and Roth and Calabrese Calabrese-Barton, *Rethinking Scientific Literacy*.

students, like scientists, work with one another.[491] *SFAA* and the *Standards* both support collaboration in the science classroom. *SFAA* criticizes "the present science textbooks and methods of instruction," which "fail to encourage students to work together, to share ideas and information freely with each other."[492] Similarly, the *Standards* encourage teachers to develop communities of science learners, where collaboration among students is nurtured.

Some of the Gilded Age scholars reviewed in this chapter had similar notions. In point of fact, this issue was not raised at all by any of the scholars in *CDML*, although it can be seen in the discourse of other scientists and scholars of the Gilded Age, specifically that of Josiah Cooke and William Whewell. These scholars saw the need to educate students in matters similar to their present-day counterparts. Cooke and Whewell saw the need to educate future scientists about the collective and cooperative nature of science; they recognized the fact that future scientists should learn early in school that scientific invention is never the work of one man but rather the cooperative work of many scientists over many years.

Organization of Knowledge

Modern day scholars of scientific literacy partly define scientific literacy in terms of the organization of scientific knowledge. Here, a scientifically literate individual has some knowledge and understanding of the basic facts and principles of science and the basic vocabulary of science.[493] Furthermore, the scientifically literate individual possesses some of the skills of science such as the ability measure, observe, conduct experiments, analyze, predict, classify, control variables, and use both inductive and deductive reasoning.[494]

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[491] Palincsar et al., "Pursuing Scientific Literacy."
[492] AAAS, *SFAA*, xvi.
[493] AAAS, *Benchmarks*, *SFAA*; Bybee, "Achieving Scientific Literacy;" Fensham, "Science for All;" Koelsche, "Scientific Literacy;" Miller, "Scientific Literacy;" NRC, *Standards*; and Shamos, *The Myth of Scientific Literacy*.
[494] Fensham, "Science for All;" Glynn and Muth, "Reading and Writing;" Koelsche, "Scientific Literacy;" Palincsar et al., "Pursuing Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.

As has been shown throughout this chapter, Gilded Age scholars recognized that the progress of science depended upon the identification and training of future scientists. Learning the basic facts and principles of science would help future scientists to waste less time learning science on their own, waste less time pursuing impossible experiments, and give them a starting block for future scientific work.[495] By wanting students to have an understanding of the basics facts, principles, and vocabulary of science, the Gilded Age scholars were advocating for scientific literacy.

Surprisingly, the Gilded Age literature examined in this chapter is devoid of reference to teaching the skills of science. With that said, one can imagine that by arguing that the teaching of future scientists would aid in the progress of science, the Gilded Age scholars may have been implying that future scientists should learn some of the skills of science. The same would seem to hold true for the personality traits necessary to scientists – honesty, open-mindedness, curiosity, skepticism, and the ability to identify and address one's assumptions. These are positive character traits for the scientifically literate individual to have, and a science education that would educate future scientists might presumably inculcate some of these character traits and skills in the students. Again, this was not an explicit part of the discourse about educating future scientists, so should not be taken as more than conjecture based on my analysis of the literature.

Progress of Science

Within the modern day literature on scientific literacy I have discovered that there is a minor nuance where scholars are advocating for scientific literacy for the purpose of helping science itself to progress. These scholars would not consider the progress of science itself as the sole purpose or criterion of scientific literacy; rather, the progress of science is a minor aspect of

[495] Paget, J., "Study of Physiology;" and Carpenter, "Extracts."

the rationale for a science education that advances scientific literacy.[496] The same point can be confidently said about the Gilded Age scholars. Scholars like Edward Livingston Youmans and James Paget held a notion similar to their modern day counterparts, namely that science should be taught for the sake of scientific progress. Furthermore, the Gilded Age scholars, like their modern day counterparts, made the progress of science only a minor aspect of their rationale for teaching science.

Although a few late-twentieth century scholars such as Milton Pella and Peter Fensham recognize that both scientists and the community as a whole must be scientifically literate in order for science to progress, most modern day scholars who discuss scientific literacy do not address the progress of science itself as a reason to promote scientific literacy.[497] For their part Gilded Age scholars seem to have been much more open to the notion that the purpose of science education was to help in the progress of science. The scholars in *CDML* did not, unlike their present-day counterparts, shy away from the argument that science education could help achieve scientific progress. Why this topic is not more prominent in the modern day literature on scientific literacy may be due to the fact that today, as in the Gilded Age, science education was primarily concerned with teaching everyone (not jut future scientists) science so that they could use scientific ways of thinking and knowing in their everyday lives.

It is interesting to note that there is a bit of modern day discourse in the literature on scientific literacy that pertains to the promotion or aid to industry and economics. Improving America's economic competitiveness and keeping pace with our capital accumulation are two subjects prominently seen in the late-twentieth century discourse.[498] This is strikingly analogous

[496] Apple, "Educational Reform;" Culliton, "Dismal State;" Fensham, "Science for All;" NRC, *Standards*; and Pella, "Scientific Literacy."
[497] Fensham, "Science for All;" and Pella, "Scientific Literacy."

to Gilded Age scholars like Josiah Cooke and Daniel Coit Gilman who advocated for the teaching of science so that scientific progress could aid America in its national greatness and influence. So, while Cooke and Gilman were not explicitly advocating for scientific literacy, their ideas have parallels to modern day definitions of scientific literacy.

Conclusion

To review, the main argument explored in this chapter was that science should be taught in the secondary schools in order for the progress of science to continue. The national obsession with progress was reviewed, with particular attention paid to the fact that science was the material face of progress in the Gilded Age, and that this was something the scientists capitalized on in their contributions to the discourse. By taking advantage of the public's infatuation with progress, the scientists called for science education as a way to identify and train future scientists; those students with natural preferences and aptitudes for science could be identified and taught the foundations of science. Teaching future scientists something of the nature of science and some of the history of science was another aspect of science education for the sake of the progress of science itself. Also included in this discourse were those students without any inclination to pursue scientific careers; by teaching them science in the secondary schools we would be creating an enthusiastic and supportive public to help finance and encourage scientific progress.

The progress of science was a valid topic for Gilded Age scholars advocating for including science in the curriculum. The cult of progress, the nation's infatuation with progress, and the fact that science and technology were the face of progress were powerful influences in Gilded Age society. While modern day educators may acknowledge that scientifically literate individuals are a necessary aspect of the progress of science, Gilded Age scholars, particularly the scientists, were more than willing to acknowledge this fact – they used the power of science to their advantage and included it as a significant argument in their case for including science in the curriculum.

Studies should be wisely selected, attention being paid to the needs of the majority.

Burke Aaron Hinsdale, *Schools and Studies*

CHAPTER 7

SOCIAL JUSTICE

Introduction

My focus with this research has been, as the previous chapters have shown, to understand the major rationalizations put forth by Gilded Age scholars for including science in the secondary school curriculum. The research has been organized along the lines of the five most pronounced arguments, namely modern knowledge, functional education, scientific fraud, public health, and scientific progress. Until this chapter there has been no mention made of social justice implications in my research, with the rationale that I would look at the entire body of literature through a social justice lens rather than look at each of the five nuances in turn.

The arguments that have been analyzed in the previous five chapters were not inherently social justice arguments; rather, social justice issues are something that I am imposing on the arguments. The goal is to determine if the primary sources tell us anything about violence and racism – that is, social justice - in the intellectual discourse. For this investigation, an exploration of social justice issues in the sources will be a combination of understanding what *is* said, what is *not* said, who is implicitly and explicitly *not* included in the rhetoric, and a bit of reading between the lines.

There are two reasons for exploring the Gilded Age literature through the lens of social justice. The first reason is to see if any of the social inequalities that were widespread in Gilded Age society are manifest in the literature. We know through social histories of the time that social injustice was a reality, but this is an intellectual history, and my intent here is to determine the reality of social injustice in the intellectual discourse of the time.

From social histories we know that the Gilded Age was a time of terrible economic inequalities that resulted in grave disparities in living conditions, employment opportunities, and life expectancy. Men like John D. Rockefeller, Andrew Carnegie, and Cornelius Vanderbilt were worth $6 billion, $2.5 billion, and $4.7 billion respectively in roughly 1880, while workers in the building trades, glassmaking trades, and stone working trades earned $10.54, $8.57, and $10.25 a month respectively in 1880.[499] The average life expectancy in 1880 was approximately 40, but individuals like Cornelius Vanderbilt, William Waldorf Astor, John Jacob Astor III, and Andrew Carnegie lived to the ages of 83, 71, 62, and 74 respectively.[500] In terms of living conditions, the Vanderbilt family lived in a 175,000 square foot home with 250 rooms, while five impoverished families lived together in a single 12 foot by 12 foot room.[501] Social injustice rode rampant through the Gilded Age, but was this social inequality a part of the literature that has been explored for this research?

In terms of educational inequalities of the Gilded Age, social justice issues are widespread in the history of American schooling; groups were excluded, segregated, and assimilated in various fashions at various times and in varying degrees. This point is not under

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[499] The net worths of Vanderbilt, Carnegie, and Rockefeller come from "Wealthiest Americans Ever." The weekly wages of the other professions come from Wright, *Comparative Wages*.
[500] Boyer, "Life Expectancy."
[501] Information about the Vanderbilt house comes from "Biltmore Estate," http://en.wikipedia.org/wiki/Biltmore_Estate, retrieved November 16, 2009. The information about the five families living together comes from Riis, *how the Other Half Lives*.

contention, nor should it be, as anyone looking at the history of American schools through a social justice lens can easily see that this is the truth. However, there is evidence that amidst widespread social injustices, some headway was being made for disenfranchised groups. For example, during the Gilded Age females were able to obtain varying degrees of education through female academies, normal schools for teachers, and even some colleges.[502] African Americans and Asian Americans had some access and were also receiving some level of education, although theirs was a segregated and inferior education.[503] The reality of social inequalities in the schools is an issue for social history, (see for instance: Joel Spring's *The American School*) whereas this research is an intellectual history. The point under investigation here is the extent to which social justice issues penetrated the intellectual discourse of the Gilded Age.

The second reason to investigate the Gilded Age literature through the lens of social justice is to create perspective and depth of understanding about issues of rights and equality that are important in our present day society. This is especially important as *SFAA*, the *Benchmarks*, and the *Standards* all call for science for all. The AAAS wrote that scientific literacy applies to "all young people, regardless of their social circumstances and career aspirations. In particular, the recommendations pertain to those who in the past have largely been bypassed in science and mathematics education; ethnic and language minorities and girls."[504] For their part, the NRC wrote that scientific literacy applies "to all students, regardless of age, gender, cultural or ethnic background, disabilities, aspirations."[505] Social equality, in the form of teaching science to all students, is a major underlying belief of our modern day rationalization

502 Arnold, "Women's Education;" and Spring, *American School.*
503 Spring, *American School*.
504 AAAS, *SFAA*, xviii.
505 *Standards*, 2.

for scientific literacy. As such, looking at Gilded Age literature as it pertains to scientific literacy through a social justice lens will help bring the historical literature within reach of the modern day rationale for scientific literacy.

Class Discourse

In most social contexts, it is typically the dominant group's ideology that manifested itself in the literature, as it was the dominant group who had access to the modes of idea production and dissemination, and it was the dominant group who had the time and energy to be career intellectuals. As Carl Kaestle, a twentieth century educational historian, wrote, it is hard to discern the ideology of ordinary people in a time when print resources were not widely available to all members of society.[506] Louis Menand, a twenty-first century historian, put this idea in a more sociological context when he wrote that "if groups define themselves by their differences from other groups, a change in the status of one group affects every group that defines itself in relation to it."[507] It may be that the intellectual discourse was actively meant to keep each group in its place, making sure that each group (i.e., the dominant group) stays put; more than this though, it may be that certain voices and events and discourse were silenced and left out in order to maintain the status quo.

The dominant group in this case was the intellectuals whose works have been explored in this research – these were the men with access to printing resources and were career intellectuals, scientists, and educators. Carl Kaestle characterized the leaders of education as Anglo-American, Protestant, middle class, and holding the ideals of Republicanism and capitalism.[508] Lawrence Cremin, in his educational history, characterizes the same group of men, using the term *late American Victorian* to describe the urban elites of the Gilded Age. Cremin's defining terms

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[506] Kaestle, *Pillars of the Republic.*
[507] Menand, *The Metaphysical Club,* 396.
[508] *Pillars of the Republic.*

identify the men as Protestant, middle class, self-conscious, receptive to new science, cosmopolitan, and holding the ideals of evangelicism.[509] Richard Hofstadter, another modern day historian, used the term "genteel reformers" to characterize the urban elites of the Gilded Age, informing his readers that these men came from the Northeast - Massachusetts, Connecticut, New York, and Pennsylvania.[510] Most importantly, career intellectuals have been characterized by historians as men of breeding, intelligence, taste, and substance; they were a leisured patrician class that was elitist in its manner of thinking and functioning.[511]

Few historians in the twentieth century have examined conceptualizations by Gilded Age scholars of the linkages between science education and class; the secondary literature points out only the perceived elitism of a classical education. Theodore Sizer, in his educational history, maintained that Americans objected to the class pretensions associated with classical study, and Caroline Winterer, in her history of the classical curriculum, concurred that there were class pretensions associated with classical study since it was seen as an education for scholars and gentlemen, not for the working classes and businessmen.[512]

Interestingly, class-based rhetoric comes up more frequently in the Gilded Age literature than one would suppose given the paucity of it in the secondary literature. With that said though, the majority of scholars did *not* discuss class. This may be explained by looking at the characteristic of the Gilded Age scholars themselves. The characteristics of the scholars and the ideologies that they adhered to were also the characteristics and ideologies of the intended audience of their words and the intended beneficiaries of their reform; specifically, middle and upper class, white, Protestant, Anglo-American males were involved in this discourse. Because

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[509] *Metropolitan Experience*.
[510] *Anti-Intellectualism*, 174.
[511] Sproat, *Best Men*, vii; and Hofstadter, *Anti-Intellectualism*.
[512] Sizer, *Age of the Academies*; and Winterer, *Culture of Classicism*.

these characteristics and ideologies were shared by not only the scholars themselves but also by their audience and their intended beneficiaries, it would seem a logical conclusion that class distinctions were unnecessary to state, as everyone involved assumed that it was their own class being discussed. And it was, for the most part, left unsaid, where the assumed beneficiaries and audience were of the same class as the scholars.

The goal here, however, is to uncover those scholars who *did* discuss class in order to further understand the Gilded Age mindset and discourse. The final section of *CDML* comes from extracts of testimony given by scientists before the English Public Schools Commission, with William Carpenter, Joseph Hooker , Charles Lyell, and Richard Owen being four prominent examples. These four men all made reference to class, although it is important to note that each was specifically asked a question by the commission in reference to class. In fact, the commission merely asked each man if he had noticed any differences in the scientific knowledge of the wealthy, middle, and poor classes. So, while Carpenter, Hooker, Lyell, and Owen may have mentioned something about class in their discourse, it was simply to say that there were no appreciable differences in scientific knowledge (or rather the lack of scientific knowledge) between the various classes.[513] Whether or not the various classes were meant to benefit from educational reform was not an explicit concern of these four scholars, although it may very well have been a concern of the English Public Schools Commission.

Others Gilded Age scholars examined in this research did, however, elucidate on the class aspects of science education. The Committee of Ten's *Report* suggested that "every subject which is taught at all in a secondary school should be taught in the same way and to the same extent to every pupil so long as he pursues it, no matter what the probable destination of the

[513] Carpenter, "Extracts;" Hooker, "Extracts;" Lyell, "Extracts;" and Owen, "Extracts."

pupil may be, or at what point his education is to cease."[514] At least in theory, all classes would receive an equal education. James Paget, in his advocacy for teaching physiology, had a message similar to that of the Committee of Ten. He saw the value of teaching all classes physiology, presumably since disease and sickness is not class-conscious.[515] For his part, William Hodgson was more thorough about his pronouncement on educating all classes, writing that economic science could benefit all classes. Hodgson clarified what he meant, writing that capitalists and legislators needed to know economic science in order to legislate on such matters, and that the upper classes were too self-indulgent and needed to learn economic science to combat their self-indulgence.[516] Taking his examples into consideration, it seems that while Hodgson said economic science could benefit all classes, he really meant that it could benefit the middle and upper classes. Hodgson typifies the underlying assumptions in the discourse, that only the middle and upper classes were being addressed.

John Tyndall was one Gilded Age scholar who actually talked about all classes and *meant* all classes. He illustrated how a science education (specifically physics) could benefit various classes – firstly, intellectual education was beneficial to all classes (many Gilded Age scholars would probably have disagreed with him on this point, as the lower and working classes were felt to not need an intellectual education since many manual jobs simply required working with one's hands not one's brain); secondly, politicians could benefit from knowing science because they may have to legislate on scientific issues; thirdly, drunkards in the working classes would gain good moral influence from learning science; fourthly, factory workers might be more interested in their work if they knew some science; and finally, coal miners might be motivated

[514] *Committee of Ten*, 17.
[515] "Study of Physiology."
[516] "Study of Economic Science."

to develop safer practices if they knew some science.[517] While Tyndall was relatively thorough in his discourse, upon closer examination his rhetoric of equality rings somewhat hollow; by educating "all" Tyndall meant Members of Parliament (MPs) and working people (i.e., foundry, factory, and coal mine workers). This is hardly a satisfactory representation of all people, but at least Tyndall directly discussed classes other than the middle and upper.

Rather than directly address specific social or economic classes, Burke Aaron Hinsdale made the point that the needs of the majority should determine the curricula.[518] Hinsdale's point may have come from a similar place as John Tyndall's, namely that all classes should be included in the discourse about teaching science in the schools. Hinsdale was specifically addressing the classical curriculum at this point in his essay, *Studies in Education*, and the underlying assumption Hinsdale made here was that the classics were not relevant for the majority of students, exemplifying the notion, as explored in Chapter 2, that the classics were elitist and not appropriate for education in a democracy. Interestingly, rhetoric like this might have helped serve the classicists in their later arguments, when they decided to embrace the elitism of the classics (rather than argue for the universality of their studies), holding the glorious inutility of those studies on a pedestal.

Some Gilded Age scholars specifically addressed the challenges faced by people occupying lower economic classes in their discourse, although by addressing the education of the lower classes the Gilded Age scholars were simply making the point that the middle and upper classes were the ones that would ultimately benefit from the educational system. James Pillans, a classicist, actually approved of teaching science to the lower classes, which he called the "non-

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[517] "Study of Physics."
[518] *Studies in Education*.

educated classes," since the classics would not benefit these classes anyhow.[519] Here we can see that the discourse is actually meant to benefit the middle and upper classes, those who would benefit from a classical education, for Pillans treats science as an inferior subject, one that would only serve the lower classes. Herbert Spencer did something quite similar in his discourse. He wrote that political science could benefit all classes, specifying that by teaching the members of the working classes how to execute their political power, the system of representation would be safeguarded. This seems like an honest enough point, but Spencer went on to write that the educated classes should settle certain political issues (e.g., the limits of government) and diffuse knowledge down to those below before the power was out of their hands.[520] Here again, the rhetoric ultimately serves the middle and upper classes. While Spencer seemingly advocates for the benefit of all classes (and to a certain extent, he does advocate for the lower classes to be able to represent themselves and their interests), it is fundamentally the classes holding power and determining law that will benefit.

Some Gilded Age intellectuals were simply more forthright about the fact that it was the middle and upper classes that were going to benefit from educational reform. Sir David Brewster, a Gilded Age polymath, was possibly the most straightforward, saying, "It is to the middle, and even to the upper classes, and through them to the nation, that science teaching will offer its richest benefits."[521] Brewster specifically meant that lawgivers, statesmen, and judges (i.e., the functionaries who administer the affairs of the state) would benefit from a scientific education. Daniel Quinn was of much the same opinion, specifically having statesmen, clergy, lawyers, doctors, literary men, and scientists in mind as the beneficiaries of educational reform;

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[519] "Utility of Classical Instruction," 229.
[520] "Political Education."
[521] "Opening Address," 178.

these were the leaders of the people, the men who molded and influenced public opinion.[522] Quinn, like Brewster, felt that the education of those who held power was the most important function of education. Joshua Jones, a classicist, agreed that educating the leaders of society was the most important part of education; he wrote that the fitness of the teachers of the middle and upper classes was more important than the fitness of the teachers of the lower classes because the well-being of the nation and the national character of the nation depended on the middle and upper classes.[523] The opinion that the education of the middle and upper classes was much more important than the education of the lower and working classes was an implicit assumption in much of the Gilded Age discourse, for even those scholars who advocated for some aspect of education for the lower classes still meant for the middle and upper classes to benefit in the end. Again, it is not surprising that the middle and upper classes were the true beneficiaries of the educational reform discourse being examined in this research because the men advocating for reform were, themselves, members of the middle and upper classes.

Gender Discourse

Modern historians tend to agree that Gilded Age Americans held a strange mixture of both democratic and intolerant ideas about education. Carl Kaestle wrote that, "even the most ringing statements about the equality of all men were not taken to include women or black people."[524] According to Louis Menand, a present day historian, one assumption about educating women in the Gilded Age was "that for the most part the education of women was a wasteful practice."[525] While there is ample secondary literature on women's education in the nineteenth century, there is strikingly little secondary literature on discourse about teaching science to

[522] "Higher Education."
[523] "Classical Study."
[524] *Pillars of the Republic*, 92.
[525] Menand, *Metaphysical Club*, 8.

women in the nineteenth century. This lack of secondary literature is not surprising, since there was very little Gilded Age discourse about teaching women science.

As detailed above, the scholars themselves, their audience of readers, and their intended beneficiaries of educational reform were all cut from the same mold – white, Anglo-Saxon, Protestant, urban Northeasterners. The other characteristic held in common was that they were all male. Just as class was often left unsaid, with the implicit assumption that the scholars were discussing their own class, so too was gender often left unsaid, with the implicit assumption that the gender of the intellectuals, their audience, and their beneficiaries was under discussion. That boys were being discussed was self-evident to all involved, thus it was not necessary to explicitly address gender in the discourse.

Many scholars of the Gilded Age used the word “boy” in their discourse with no thought for gender. For example, a statement like “a boy can scarcely learn any science without aid of Latin” was written in an off-hand manner without a thought for the gender of those learning science and Latin.[526] The assumption that it was boys who were learning Latin and science was so implicit that using the word boy to specifically identify the gender of the students was a non-issue. Other similar expressions abound, where the term boy was used in a nebulous way. For example, Howard Rogers, of the Department of Education, wrote near the turn of the century, “In the United States every boy between the ages of five and eighteen is offered an education which may fit him to be the President,” and Daniel Quinn, a Gilded Age university professor, wrote, “a university is an institution which fits our true and proper men of the people to become leaders of the people.”[527] While these are merely a few examples, the significance here is that the

[526] Taylor, *Classical Study*, xviii.
[527] Rogers, “Paris Exposition,” 745; and Quinn, “Higher Education,” 16.

gender of those learning science or those meant to benefit from educational reform was implicit, so the use of gender pronouns was unimportant.

With that said, as with the class discussion above, there were some Gilded Age intellectuals who advocated for teaching science to both boys and girls. Most notably would be Herbert Spencer, whose listed "preparing students for parenthood" as the third most important function of education.[528] Spencer's assumption here was that both sexes should be prepared for parenthood. He also felt that it was important (and a positive outcome of teaching science) to "fit youth of both sexes" for their social and citizenship duties.[529] In a statement that advocates for teaching both sexes science, Jacob Bigelow said, "We cannot train all our boys to be statesmen and diviners, nor all our girls to be authors and lecturers."[530] The point of Bigelow's statement was that teaching science could benefit both boys and girls beyond that small subset of individuals who would enter the most visible careers and professions, thus giving them a scientific mindset for life after school.

In the influential *Report of the Committee of Ten* the discourse about gender is not entirely straightforward. The authors of this report used the term "boy," but they also used the gender-neutral term "pupil." Furthermore, the term "boys and girls" was used in the report.[531] As noted above, the men who served in the committee (and yes, all ten members of the general committee and all ten members of each of the nine conferences were men) seem to have been including all classes in their discourse, so it is probably safe to assume that they were also including both genders in the discourse.

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[528] *Education*.
[529] Ibid., 169.
[530] *Limits of Education*, 7.
[531] *Committee of Ten*, 10, 45, 51.

Thomas Henry Huxley was another Gilded Age scholar who weighed in on teaching women science. Huxley granted his readers that the "defects of women" were impediments to their learning science. Specific female defects included being not so firmly strung as men, being not so well-balanced as men, and being more excitable, timid, dependent, and conservative than men. While Huxley's words may imply that he was opposed to teaching women science, this was not the case. Although Huxley granted that women had multiple defects, he did feel that they should learn science. Women's faults aside, "they share the senses, perceptions, feelings, reasoning powers, emotions of boys," and that whatever justified a boy's education should also justify a girl's education.[532] While seemingly criticizing women, Huxley, like Herbert Spencer and Jacob Bigelow, really did believe that both boys and girls could and should benefit from learning science.

John Stuart Mill, an early women's rights advocate, reminded his readers that the "necessity has become evident to all. We say, then, to rich and poor, Tories, Whigs, and Radicals, - Are you going to educate a nation without women?"[533] In a democracy, whether the United Kingdom's constitutional monarchy (where Mill lived and wrote) or America's democracy, the notion of equality was powerful and important, and equality included women.

William Hodgson was more equivocal about teaching women science. He suggested that women learn economic science because they play a part in economic affairs.[534] Although Hodgson did support women learning science, his advocacy was not altogether liberating for women; the reasons to teach women economic science were because women bought things and played a part in charity. In other words, Hodgson still placed women firmly in inferior social positions and was quite likely addressing only women of the upper social classes.

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[532] *Science and Education*, 72.
[533] "Women's Suffrage," 376
[534] "Study of Economic Science."

Unlike my interpretation of the Gilded Age class discourse above, where even when the lower classes were being talked about it was still the middle and upper classes that were ultimately benefitting from the reform, the gender discourse for the Gilded Age seems to really imply that both boys and girls could benefit from learning science. We do not see in these statements about teaching girls science that ultimately boys would be the beneficiaries – it seems that for at least these few scholars explored here, both boys and girls were meant to benefit from teaching science.

With that said, there were various Gilded Age intellectuals who were vociferously opposed to teaching girls science. Morrison Swift, a Gilded Age sociologist, was one such individual. He wrote that women would become unfit wives and mothers if allowed to be educated. His reasoning was that women had not been trained to endure intense mental strain, that they would be injured by the use of their brains, and that excessive study and anxiety caused by tests in school would cause poor reproductive organ formation and maturity.[535]

Lois Barber Arnold, a late twentieth century historian of women's education, shed some light on the mindset of Gilded Age society as relates to women and education. Arnold wrote, "Even when women could gain access to science instruction … they tended to be channeled into segregated, gender-related curricula and activities designed to prepare then for accepted social roles."[536] Arnold's insight seems to be valid – from the small sample of Gilded Age literature above, even the men granting women access to science education did so within the confines of accepted social roles. For example, Herbert Spencer granted that girls should learn science, but only to fulfill their parenting roles; Jacob Bigelow granted that girls could learn science, but he also perpetuated the notion that girls could only become lecturers or teachers; Thomas Henry

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[535] *Education and Power*.
[536] "Women's Education," 16.

Huxley granted that girls should learn science, but he was also quick to point out some of their assumed flaws; and William Hodgson granted that women should learn economic science, but only in their capacity as shoppers and household maintenance.

Lois Barber Arnold also gave some insight into the ideologies held by many individuals during the Gilded Age and how these ideologies affected discourse on educating women. She wrote that Charles Darwin had convinced people of the natural inferiority of women and their limited capacity for intellectual achievement; that Thomas Henry Huxley, Herbert Spencer, and Francis Galton had convinced people that women were in an arrested state of development of evolution; and that measured differences in brain size and anatomy between the sexes had convinced people that these differences should result in differing education.[537] None of the Gilded Age scholars reviewed in this research explicitly reveal any of these points except for Huxley who pointed out some of the commonly accepted flaws of women. Leaving these ideologies left unsaid, however, does not necessarily mean that these men did not hold to these ideals. After all, Huxley and Spencer themselves were intimately involved in the discourse on science education, so they must have held to the notions that they convinced others of. In other words, just because these men were silent on these beliefs does not mean that they were not underlying assumptions of their words.

Race Discourse

Twentieth century historians of education have made some insightful conclusions about Gilded Age beliefs about the equality between different races and ethnic groups. As noted above, Carl Kaestle maintained that Gilded Age statements about equality did not actually include women or non-white people.[538] While Gilded Age scholars may have believed in equality and

[537] Ibid.
[538] *Pillars of the Republic*.

fair opportunity for everybody, they also believed that certain groups were inferior and unable to benefit from education. Thus it was their definition of "everybody" that gives meaning to these apparently disparate beliefs expressed by scholars in that period. According to Joel Spring, a modern day educational historian, educators "preached equality of opportunity and good citizenship while engaging in acts of religious intolerance, racial segregation, cultural genocide and discrimination against immigrants and nonwhites."[539] Spring interpreted the entire history of American schooling through a lens of racism, writing that conflicts over cultural domination were rampant throughout.[540] Spring goes to great lengths to prove his point, but the validity of what actually occurred in the schools is not the focus of this research. Rather, this research focuses on the intellectual discourse of the Gilded Age, and Spring's point, while valid for lived experiences, may or may not be valid for the discourse.

Historians studying the nineteenth century believe that before Charles Darwin and Herbert Spencer fleshed out the theory of evolution by natural selection most people held one of two beliefs about the different races. Those holding to the theory of monogeism believed that all races were created at the same time but that there were differing rates of degeneration among the races, where some races had declined more than others. Those holding to the theory of polygeism simply believed that the races were created separately.[541] Either way, both of these theories were predicated upon the belief that there were ingrained differences in the various races. More importantly, both theories were hierarchical, where white people (or, even more specifically, white people of northwestern European descent) were at the top of the hierarchy. After the notion of survival of the fittest surfaced it was applied to society (i.e., Social Darwinism), where the fittest members of society naturally were meant to survive or thrive.

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[539] Spring, *The American School*, 5.
[540] Ibid.
[541] Menand, *Metaphysical Club.*

According to Louis Menand, a modern day historian, this simply justified the existing social hierarchies.[542] Whether the belief was that the races degenerate differently, that the races were created separately, or that the fittest individuals thrive, differences between the races was a significant social topic during the latter part of the nineteenth century.

The most significant group to be discussed in this respect was African Americans. (Note: The term African American was not used during the Gilded Age. Instead, they used the terms *black* or *negro*. As such, the Gilded Age terms will be used here only when directly quoted from Gilded Age literature.) According to one twentieth century historian, the generally accepted wisdom of the day was that African Americans were both physically and emotionally constitutionally different from white people.[543] It can probably be inferred from this statement that *different* meant *inferior*. John Sproat, another twentieth century historian, had this to say about the Gilded Age white person's view of African Americans: "Like most white Americans, liberals viewed the Negro in stereotypical, but oddly ambivalent, terms … they thought it self-evident that Negroes were innately inferior to whites in their intelligence, ability, and moral capacity."[544] The existing social hierarchy of whites and African Americans would surely be kept intact with sentiments like these.

Carl Kaestle, in his analysis of educational reform, gave his interpretation of the discourse of the time; he wrote, "Blacks remained outside of the cosmopolitan rationale" of school reform.[545] Lawrence Cremin, in his analysis of educational reform, found that the general belief was that African Americans were inassimilable and that educating them would not add to their happiness. In fact, this belief extended beyond happiness and satisfaction to include the idea

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[542] Ibid.
[543] Goodman, *Sun and Moon*.
[544] *Best Men*, 29.
[545] *Pillars of the Republic*, 179.

that African Americans, due to their inferior race, would not profit from education anyhow.[546] How much of these ideas are seen in the discourse on teaching science? Did the intellectuals merely leave African Americans out of the discussion, with the assumption that they were uneducable, or was there any discourse that included African Americans?

The simple answer to this question is that Gilded Age intellectuals talking about teaching science simply left African Americans out of the discussion. Only one single individual examined in this research so much as mentioned the racial group, and not in a flattering way. Thomas Henry Huxley wrote, “No rational man, cognizant of the facts, believes that the average negro is the equal, still less the superior, of the average white man,” and that “the highest places in the hierarchy of civilization will assuredly not be within the reach of our dusky cousins.”[547] Huxley’s point in writing about African Americans was ultimately to say that they could educate themselves if they wanted, but since they had been granted some level of political freedom, they were no longer the concern of white people. While Huxley may have voiced an opinion held by many others, not one single other individual examined here included African Americans in the discourse. The discourse examined here, namely those writings based in the *Culture Demanded by Modern Life* that advocated for including science in the curriculum, was wholly silent on the issue; the entire racial group was completely excluded from the discourse, as the educational needs of African Americans truly were outside the rationale given for the necessity of teaching science by these scholars.

Finally, other groups like Native Americans, Mexican Americans, Puerto Ricans, and Asian Americans were similarly omitted from the discourse. The Reverend Edward Hitchcock, president of Amherst College, summed up the common view of these groups: “By Americans,

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546 *National Experience*.
547 *Science and Education*, 67.

however, I do not mean that motley crew, of all colors, and temperaments, and languages, and religions, which is annually disembogues upon our shores; but those in whose veins there flows some of the pure Saxon blood, that came over in the May Flower."[548] Plainly put, those individuals and groups who fell outside of the small subset of the intellectual themselves (i.e., everyone who was *not* white, Anglo-Saxon, Protestant, and middle or upper class) were simply excluded from the rhetoric; their voices were silenced, they were not given representation in the discourse, and they were outside of the reasoning of the discourse.

Conclusion

In conclusion, the most straightforward interpretation to be made from the Gilded Age discourse on teaching science in the secondary schools is that the educational needs of those social and economic groups of people who were not white, Anglo-Saxon, Protestant, and middle class were outside of the rationale for the inclusion of the teaching of science in the school curriculum. While the Gilded Age scholars may have been reasonably thorough in their reasoning for including science in the secondary school curriculum, they were not at all thorough about whom they intended to benefit from including science in the curriculum. Of course the Gilded Age scholars did not explain to their readers *why* they chose to leave certain groups out of their discourse, so we can only speculate as to the reasons why they did so. Maybe their omission of groups outside of their own were due to ingrained cultural biases of the Gilded Age, where it was assumed that African Americans were an inferior race who could not benefit from education, or where it was assumed that women had inborn defects that meant that they too could not benefit from education in the same way as boys could. Finally, the reality that the poor classes were preoccupied with survival meant that they too would not benefit from a scientific education, since their livelihoods depended on manual dexterity, not mental dexterity.

[548] "American Academic System Defended," 100-101.

Maybe the Gilded Age scholars did not address groups such as African Americans, women, and the poor in their discourse because they knew that these groups were being educated elsewhere, in such places like segregated schools, church schools, southern plantations, normal schools, and academies. Perhaps the scientists whose scholarship has been explored in this research assumed that these groups would be taken care of by other scholars and educators, thus leaving them out of their own discourse.

Finally, perhaps the Gilded Age scholars left groups other than their own out of the discourse as a subtle way of holding on to power. As mentioned at the beginning of this chapter, it was the dominant group's ideology that manifested itself in the literature because it was the dominant group who had access to the modes of idea production and dissemination, and it was the dominant group who had the time and energy to be career intellectuals. If, in fact, the dominant group wanted to hold on to their power, leaving other groups out of their discourse would have been one such way to achieve this goal. Lastly, if Louis Menand is correct by saying that "if groups define themselves by their differences from other groups, a change in the status of one group affects every group that defines itself in relation to it,"[549] then by silencing the voices of all other groups, the dominant group is able to maintain its prominent place and hold on power.

[549] Menand, *The Metaphysical Club,* 396.

CHAPTER 8

CONLCUSION

Scientific Literacy for Social Responsibility

In the modern day educational literature, the notion of promoting scientific literacy for social responsibility characterizes by far the most frequent reasons given for promoting scientific literacy. This idea of promoting scientific literacy as a means to encourage social responsibility covers those social norms that relate to responsible and active citizenship such as being able to understand scientific issues one reads in the media, being able to discuss these issues knowledgeably, and, moreover, being able to make informed democratic decisions about scientific issues. Possession of this component of scientific literacy is less about having an understanding of the concepts and principles of science and more about access to scientific decision-making skills and the ability to participate in a democracy where scientific issues arise. Michelle McGinn and Wolff-Michael Roth view it as, "scientific knowledge as competence in scientific discourses rather than as bodies of facts and theories."[550]

The defining term for this category is arguably "citizen," with expressions such as "effective citizenship," "productive citizens," "informed citizens," "concerned citizens," "good citizenship," and "citizen science" commonly found.[551] The idea that a good citizen is one who

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[550] McGinn and Roth, "Preparing Students," 19.
[551] Ibid., 17; AAAS, *SFAA,* xiii; and Kolstoe, "Consensus Projects," 645, use the term "citizen." Culliton, "Dismal State," 243; and Miller, "Scientific Literacy," 1, use the term "effective citizenship." Hurd, "Scientific Literacy," 407, uses the term "productive citizen." DeBoer, "Scientific Literacy," 592; and Ewing, Campbell, and Brown, "Improving Student Attitudes," 350, use the term "informed citizens." Eisenhart et al., "Conditions for Scientific Literacy," 285, use the term "concerned citizens." Lee and Roth, "Science and the 'Good Citizen'," 403, use the term "good citizenship." Roth, "Scientific Literacy," 13, uses the term "citizen science."

can participate in the democratic process is fundamental to present day scholars who advocate for scientific literacy based on social responsibility.

Most modern day scholars agree that being identified as scientifically literate includes being able to make informed decisions about scientific and technological issues that are in the national public agenda. In other words, scientific literacy involves using decision-making skills in an informed way with regard to scientific issues.[552] Scientific issues in the public agenda could include things like nuclear power, acid rain, genetic engineering, food and agriculture, drugs, cancer, recycling, sanitation, and pollution, just to name a few.

Part of being able to make informed decisions about scientific issues in the public agenda is being able to understand discussions of these things in the popular media.[553] While Charles Koelsche measured the vocabulary and knowledge of scientific concepts needed to interpret and understand the material in science articles and printed news items, this is not an exhaustive list of what is necessary for scientific literacy in this sense.[554] One must be able not only to understand what is printed and heard in the mass media; one must also be able to interpret it, make informed decisions about it, and form relevant, logical, and independent conclusions about it. Furthermore, being able to construct a good argument and understanding what it takes for others to construct convincing arguments is another science skill that plays a part in understanding scientific discourse in the mass media.

What is more important still than being able to understand and interpret scientific discourse in the mass media is being able to evaluate and make critical judgments about science

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[552] Hurd, "Scientific Literacy;" Kolstoe, "Consensus Projects;" Lee and Roth, "Science and the 'Good Citizen';" Meehan, "Nuclear Safety;" Miller, "Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.
[553] DeBoer, "Scientific Literacy;" Ewing et al., "Improving Student Attitudes;" Glynn and Muth, "Reading and Writing;" Koelsche, "Scientific Literacy;" and Oliver et al., "The Concept of Scientific Literacy."
[554] Koelsche, "Scientific Literacy."

and scientific authority (i.e., "informed skepticism").[555] For some, the ability to make critical judgments about scientific authority involves knowing when to seek expert advice and where to find access to a responsible expert's advice.[556] Here again we see the notion that being able to make critical judgments about science and scientific authority rests more on one's decision-making skills and competency in scientific discourse than on one's knowledge of the facts of science.

By examining the modern day literature on scientific literacy, as I carried out my literature review on the topic and then re-examined the literature as I examined each of the five Gilded Age arguments for teaching science, a simple definition of this modern day nuance began to take shape. It became increasingly manifest that a straightforward definition for scientific literacy for social responsibility was: using scientific ways of thinking in one's everyday life.

As I thoroughly explored the Gilded Age literature on the rationale for including science in the secondary school curriculum, it also became increasingly clear that our modern day notion of scientific literacy as relates to social responsibility was the modern day nuance of scientific literacy with the most comparable grounding in societal needs to those presented by Gilded Age scholars. Each of the Gilded Age arguments for including science in the curriculum (i.e., modern knowledge, functional education, scientific fraud, public health, and scientific progress) is examined here more closely in the context of scientific literacy for social responsibility. While I have examined each of the five Gilded Age arguments through the lens of scientific literacy in each chapter, my purpose here is tie together the various Gilded Age arguments under the most significant modern day aspect of scientific literacy, namely social responsibility.

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[555] AAAS, *SFAA*, 186; Kolstoe, "Consensus Projects;" McGinn and Roth, "Preparing Students;" and Shamos, *The Myth of Scientific Literacy*.
[556] DeBoer, "Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.

Modern Knowledge and Scientific Literacy

As detailed in Chapter 2, "Modern Knowledge," Gilded Age scholars were mindful that updating the curriculum to include science had implications for citizenship roles and social responsibilities; in other words, scientific literacy for social responsibility was a facet (although not specified as such) of the Gilded Age argument for teaching science. It should be remembered that one argument for updating the curriculum to include science was to make it more appropriate for the education of people living in a democracy, as many people felt that a classical curriculum was not relevant for that purpose. It was further elucidated in Chapter 2 that Gilded Age scholars recognized that citizenship roles in a democracy require the ability to make decisions on a great variety of issues in society, particularly those issues that are scientific in nature. David Brewster and Daniel Quinn specifically referenced the players in a democracy like judges and juries, lawgivers and statesmen, and those responsible for molding public opinion (e.g., clergy, physicians, and business men) as needing an understanding of science to responsibly carry out their citizenship duties.[557]

Modern day scholars advocating for scientific literacy for social responsibility have similar notions. For example, Stein Kolstoe feels that science education should promote effective citizenship, where scientifically literate citizens are necessary for "thoughtful decision-making in a democracy."[558] For their part, Michelle McGinn and Wolff-Michael Roth's discourse sounds somewhat like the Gilded Age discourse when they write that their vision of scientific literacy prepares for "competent participation in scientific laboratories, activist movements, the judicial system, or other locations/communities where science is created and used."[559] Like David Brewster and Daniel Quinn, McGinn and Roth recognize that various players in a democracy

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557 Brewster, "Opening Address;" and Quinn, "Higher Education."
558 "Consensus Projects," 645.
559 "Preparing Students," 14.

have societal roles that necessitate an understanding of science. Milton Pella, one of the earlier modern day scholars of scientific literacy, defined scientific literacy in 1967 in terms of social responsibility in a democracy. He wrote that unless the public has an understanding of the implications of scientific development on society, the "democratic process is endangered."[560] As Pella exemplifies, the Gilded Age notion that scientifically literate citizens are necessary in a democracy and that science is a necessary part of the curriculum in a democracy, persists today.

Functional Education and Social Responsibility

The Gilded Age argument for teaching science for utilitarian purposes, as was seen in Chapter 3, "Functional Education," was based on the notion that science could both train the mind and provide useful knowledge and skills at the same time. Those advocating for science wanted students to know something of issues outside of school, but more importantly they wanted students to be able to think in ways similar to scientists on issues in the public agenda. Especially with regard to scientific controversies that came to the forefront as social issues, it was important that students to be able to understand what they read and hear about scientific issues, interpret this information, and, if necessary, make informed decisions about it. Reading about or hearing from others about something like the theory of evolution by natural selection would have been just such a case where an individual would need the thinking tools and scientific knowledge necessary to make an informed opinion. In fact, one of the motivating factors for this discourse was the increasingly scientific nature of society during the Gilded Age which created a vision of the necessary preparation of people to live in that scientific world. A functional education would, as one of its outcomes, have prepared students to live in and be responsible citizens in the increasingly scientific and technological world.

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[560] Pella, "Scientific Literacy," 347.

Modern day education scholars discussing scientific literacy have similar mindsets when compared to their Gilded Age counterparts and no more so than in advocating for a more functional education. A major facet of the modern day discourse on scientific literacy has to do with preparing students for "socio-scientific decision-making and scientific problem-solving."[561] In other words, addressing and making informed decisions about controversial scientific issues in the public agenda is a major concern of modern day scholars of scientific literacy.

Just like Gilded Age scholars, modern day scholars are also motivated by the rapidly increasing scientific nature of society. George DeBoer writes that scientifically literate students should be prepared to deal with the remarkable "rate of scientific and technological change taking place in such areas as nuclear energy, space exploration, cell biology, and brain physiology, as well as the vastly more complex social organizations."[562] Jon Miller feels much the same way, mentioning nuclear power, acid rain, the condition of the ozone layer, and the safety of genetically-engineered hormones as scientific changes in society that people need to be able to understand and make informed decisions about.[563] Other modern day scholars like Avi Hofstein, Robert Yager, Richard Meehan, Paul DeHart Hurd, Wolff-Michael Roth, and Rodger Bybee also cite social issues with a scientific basis (e.g., nuclear energy, pesticide use, drug use, rockets, missiles, birth control, health and disease, and the energy crisis) in the public agenda that require a scientifically literate citizenry to understand, interpret, and make decisions about.[564] The National Research Council is broader in their rhetoric about advocating for scientific literacy as a way to address the educational needs of people with regard to the

[561] Holbrook and Rannikmae, "Nature of Science Education," 1347.
[562] "Scientific Literacy," 586.
[563] "Scientific Literacy."
[564] Hofstein and Yager, "Societal Issues;" Meehan, "Nuclear Safety;" and Miller, "Scientific Literacy," all cite nuclear energy. Hurd, "Science Literacy," cites pesticides and drugs. Hurd, "Science Literacy;" and Roth, "Scientific Literacy," cite rockets and missiles. Bybee and DeBoer, "Goals for the Science Curriculum," cite birth control, and environmental awareness and concern. Hofstein and Yager, "Societal Issues;" and Hurd, "Scientific Literacy," cite health and disease. Hofstein and Yager, "Societal Issues," cite the energy crisis.

increasingly scientific nature of society. They write that scientific literacy is necessary for social responsibility because "the collective judgment of our people will determine how we manage shared resources – such as air, water, and national forests."[565] Whether modern day scholars are concerned about acid rain or genetic engineering, the scholars cited here are all advocating for a functional science education, one outcome of which is a scientifically literate citizenry that can respond to such issues.

Admittedly the scholars of the Gilded Age were not dealing with socio-scientific issues such as nuclear missiles and pesticide use. That does not, however, discredit their need for a scientifically literate citizenry that would be able to deal with their own current issues such as the safety of gas lighting or the uses of electric energy. In fact, while modern day scholars may think that their times are extraordinary in regards to scientific and technological advancement (and thus in need of producing scientifically literate students), the historical literature shows that men in the Gilded Age felt that they too were living through remarkable times in terms of scientific achievement.

Another facet of the Gilded Age argument for making education functional was to instill certain positive character traits in students. A disposition that included things such as prudence, foresight, sagacity, patience, humility, industriousness, independence, economy, and frugality was believed to be something that a scientific education could achieve.[566] By advocating for science to teach toward more scientist-like aspects of ones personality, Gilded Age scholars like James Paget and John Tyndall were laying the foundations for aspects of our modern day notion of scientific literacy for social responsibility, for they believed that people who possessed such

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[565] NRC, *Standards*, 1.
[566] DeMorgan, "Intellectual Attainment;" Faraday, "Education of the Judgment;" Paget, J., "Study of Physiology;" and Tyndall, "Study of Physics."

character traits would make for more responsible citizens who would be able to use these qualities in their everyday lives.

Modern day educators , like their Gilded Age counterparts, sometimes discuss the character traits that a scientific education can instill. Jack Holbrook and Miia Rannikmae, for example, stress the "promotion of character and positive attitudes" as a useful outcome of producing scientifically literate students.[567] Likewise, *SFAA*, *Benchmarks*, and *Standards*, the guiding documents of modern day scientific literacy, all advocate for instilling positive character traits in students. Things like honesty, curiosity, open-mindedness, and skepticism are explicitly recommended as positive habits of mind the scientifically literate student should possess.[568] In fact, these are some of the very same positive character traits mentioned by Gilded Age scholars, showing that this fundamental belief of our modern day notion of scientific literacy was laid down in the Gilded Age.

Scientific Fraud and Social Responsibility

The Gilded Age argument for teaching science in order to combat scientific fraud was predicated upon many of the same Gilded Age arguments for making education more functional in nature. Specifically, the Gilded age argument is largely based on the idea that science in their education could aid in giving students the ability to understand, interpret, and make informed decisions about scientific claims. In the case of scientific fraud, however, the scientific claims about which students were to be able to make informed decisions were spurious and often dishonest. While not using the terms scientific literacy or social responsibility, the Gilded Age scholars were advocating for a socially responsible and scientifically literate citizenry because they were promoting the use of scientific ways of thinking in one's everyday life.

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[567] "Nature of Science Education," 1347.
[568] AAAS, *Benchmarks*, *SFAA*; and NRC, *Standards*.

According to Gilded Age scholars, having the ability to detect and oppose scientific fraud was more often than not a matter of knowing something about the nature of science. From the Gilded Age perspective this meant things like knowing what it means to call something a law of nature, understanding what kinds of evidence and reasoning it takes to establish a scientific fact, understanding what it takes for others to formulate convincing arguments, put aside one's own biases and desire for certain outcomes, and the ability to choose one's experts wisely.[569] These tools of science would allow people to recognize pseudo-science and make their own educated decisions about scientific claims.

The modern day discourse on scientific literacy is comparatively similar in outlook, where an understanding of the nature of science is a facet of scientific literacy. In terms of scientific literacy for social responsibility, by having some understanding of the nature of science, citizens have a way of knowing about scientific knowledge and thus an ability to evaluate scientific claims. Stein Kolstoe, a twenty-first century advocate for scientific literacy, focuses on the "importance of debate, criticism, and evaluation of knowledge claims" and "knowledge of the nature and the limits of science."[570] Yeung Chung Lee, another twenty-first century advocate for scientific literacy, focuses on the use of argumentation to develop informed decision-making skills.[571] Using things like debate and argumentation are important skills of scientific literacy, but what is more, these are skills that can help individuals possess intellectual tools to combat pseudoscience.

While some of the Gilded Age examples of scientific hoaxery such as the educated fly and table rapping may seem to the modern reader to be absurdities from days past, modern day

[569] Faraday, "Education of the Judgement;" Paget, G., "Influence of Scientific Culture;" Paget, J., "Study of Physiology;" and Youmans, "Mental Discipline in Education."
[570] "Consensus Projects," 645.
[571] "Decision-making Skills."

educators are still concerned with scientific fraud. Things such as time travel, supernatural powers, spectral illusions, and prophetic dreams are examples of pseudoscience today, not to mention such products on the market that claim to enlarge certain reproductive organs, reverse ageing, or cure cancer via detoxification and internal cleansing. Position papers created by organizations such as the AAAS addresses modern day issues such as these. In general, the AAAS takes the position that a scientifically literate person would be able to distinguish between scientific and pseudo-scientific questions, even using the term "flimflam artists" to describe modern day scientific hoaxsters.[572] Modern day educators who are worried about scientific fraud may benefit from reviewing the Gilded Age literature on this subject in order to understand how their historical counterparts dealt with pseudoscience and their rationale for how teaching science and creating scientifically literate students could combat it.

Public Health and Social Responsibility

The Gilded Age goal of teaching science in order to address various public health concerns is another instance of wanting to instill scientific habits of thought in students so that they could think like scientists in their everyday lives. Once again, even though the Gilded Age scholars did not use the terms scientific literacy or social responsibility, they were advocating for scientifically literate and socially responsible citizens when they claimed that a scientific education would help people to understand health related issues in the public agenda, particularly disease, sanitation, and hygiene. More than this, scientifically literate Gilded Age individuals would have been able to make informed decisions and cast informed votes about such issues.

One particular concern of Gilded Age scholars was medical hoaxes like patent medicines and electric belts. By teaching students how to think like scientists, scholars hoped that the

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[572] AAAS, *SFAA*, xiv.

public would be more wary and discerning about medical claims.[573] Here again, knowing what it takes to make a scientific (or medical) claim, knowing how scientists go about collecting and interpreting data, and understanding other various aspects of the nature of science would equip people with the tools necessary to address medical hoaxery. In other words, an understanding of the nature of science would create scientifically literate individuals who could use their scientific understanding to address medical hoaxes.

The modern day literature on scientific literacy for social responsibility has parallels with the Gilded Age literature on issues of public health. Paul DeHart Hurd, a modern day champion of scientific literacy, addresses public health issues in his discourse on scientific literacy. According to Hurd, the scientifically literate individual would understand the concepts of health, wellness, knowledge of oneself, human growth and development, and public health issues like illegal drugs, cancer, and sexually transmitted diseases.[574] Like the Gilded Age intellectuals, Hurd's assertion here is that the scientifically literate public would be able to understand these issues, make informed decisions about them, and adapt to these issues as science and medicine progress.

While Gilded Age scholars were concerned with public health issues such as poor hygiene, pandemic diseases, and horrifying sanitation practices, modern day scholars are more concerned with public health issues like reproductive health, influencers of health like heredity and environment, and physical fitness. Although these issues may be quite different between the two time periods, particularly as the Gilded Age issues were more life threatening, scholars were still concerned with public health issues in both time periods.[575] Furthermore, it can be argued

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[573] Acland, "Early Physiological Study;" and Hodgson, "Study of Economic Science."
[574] "Scientific Literacy."
[575] For example, see Mill, "Inaugural Address;" and Huxley, *Science and Education* in the Gilded Age literature and Hurd, "Scientific Literacy" in the modern day literature.

that the characteristics of a socially responsible scientifically literate individual in both the Gilded Age and in the present would know something about public health issues and be able to deal with them in the public sector.

While scholars from both time periods discussed issues of public health, modern day scholars of scientific literacy, unlike their Gilded Age peers, do not address medical hoaxery concerns. Interestingly, medical hoaxery and pseudoscience are still present in modern day society, sometimes in quite similar manifestations as in the Gilded Age. Familiar examples of medical pseudoscience and hoaxery today include pills and medicines that claim to cure any and all ailments, just like Gilded Age patent medicines; electric hair brushes still exist; and hydropathy still exists in the form of mineral water and sauna treatments. Modern day proponents of scientific literacy for social responsibility, particularly those concerned with public health issues, should look back to the Gilded Age literature on this topic for some insight into addressing these issues today.

Scientific Progress and Social Responsibility

One aspect of the Gilded Age argument for teaching science for the sake of scientific progress was in creating a supportive and knowledgeable public that would encourage scientific work. An assumption about a public that was supportive of scientific work was that they would be able to understanding scientific issues in the public agenda, interpreting such issues, and making informed decisions about them.[576] In other words, the Gilded Age scholars felt that it was necessary for the sake of scientific progress to create a general feeling of admiration for science and scientists, an enthusiasm for scientific progress, and a public willing to support, both financially and electorally, scientific endeavors.

[576] Fiske, *Edward Livingston Youmans*; and Gregory. *Sciences and Arts*.

Modern day scholars of scientific literacy hold quite similar sentiments in this regard to their Gilded Age peers. Peter Fensham, for example, writes that science education should produce a more scientifically literate citizenry that "will be prepared to support the changes of a scientific and technological kind that are needed for a good balance between development and environmental concerns."[577] Fensham recognizes, like his Gilded Age counterparts, the need for a supportive citizenry, adding a wholly modern aspect of environmental concern to his discourse. Michelle McGinn and Wolff-Michael Roth also recognize the need for a public supportive of scientific endeavors, writing that students should "become members in a scientifically literate society that understands and appreciates science as one of its many endeavors."[578] Enthusiasm and support for science is important today, just like it was in the Gilded Age, because science is advancing today just like it was in the Gilded Age, and scientists need the fiscal and electoral support of the public today just like they did in the Gilded Age.

Conclusion

I have summed up the modern day nuance of scientific literacy as relates to social responsibility as using scientific thinking in one's everyday life. Scientific literacy for social responsibility is of ultimate importance in today's discourse on scientific literacy. Teaching students how to think like scientists so that they can meet their citizenship duties may be one of the more universally accepted aspects of a modern day definition of scientific literacy.[579] Although not everyone agrees on the meaning of scientific literacy, *SFAA*, *Benchmarks*, and *Standards* are often taken as starting points for discussion. *SFAA* starts out with the statement

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[577] "Science for All," 417.
[578] "Preparing Students," 17.
[579] For example, see AAAS, *Benchmarks*, *SFAA*; DeBoer, "Scientific Literacy;" Ewing et al., "Improving Student Attitudes;" Glynn and Muth, "Reading and Writing;" Hurd, "Scientific Literacy;" Koelsche, "Scientific Literacy;" Kolstoe, "Consensus Projects;" Lee and Roth, "Science and the 'Good Citizen';" Meehan, "Nuclear Safety;" Miller, "Scientific Literacy;" NRC, *Standards*; Oliver et al., "The Concept of Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.

that scientific literacy is "essential for all citizens," and *Benchmarks* elaborates on this, saying that citizens must be able to think critically and independently about scientific enterprises."[580] The NRC is more explicit about citizens wielding their political power, where scientifically literate citizens must be able to "engage intelligently in public discourse and debate about important issues that involve science."[581] Just like in the Gilded Age, it is important for science education to prepare students to live in a scientific world where they will be faced with scientific issues that require them to make informed decisions.

The belief that the purpose of science education is to prepare a socially responsible, scientifically literate citizenry who can deal with scientific issues in the public agenda, is the most inclusive belief seen in both the historical and modern day literature. Scientific literacy for social responsibility characterizes by far the most frequent reasons given for promoting scientific literacy in the modern day literature. Likewise, all five arguments in the Gilded Age literature (i.e., modern knowledge, functional education, scientific fraud, public health, and scientific progress) have some relevance for scientific literacy for social responsibility.

Educating individuals to be informed and active citizens who can make decisions about scientific issues in the public agenda is the most comprehensive Gilded Age reason for including science in the schools. While Gilded Age scholars did not explicitly advocate for scientific literacy, my interpretation of the literature points to the widespread belief that science education would create scientifically literate and socially responsible citizens. The argument to include modern knowledge in the curriculum included arguments about what subjects were appropriate for citizens in a democracy; the argument to make education more functional by both training the mind and imparting useful knowledge and skills was built upon the notion that thinking like a

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[580] AAAS, *SFAA*, xvii; and *Benchmarks*, xi.
[581] *Standards*, 1.

scientist in one's everyday life was a beneficial and responsible thing; the argument to teach science in order to combat scientific and medical hoaxery was predicated upon the fact that people needed to make informed decisions about scientific claims; the argument that science education should improve public health included the notion that people needed to make informed decisions about such issues in the public agenda; and the argument to teach science in the schools so that science itself would progress apace included arguments that non-scientists in the community needed to have understanding, appreciation, and enthusiasm for science so that they would support scientific research. All of these points in the end suggest that a scientifically literate citizenry is a desired outcome of including science in the curriculum.

Going Beyond the Gilded Age Discourse

The belief that the goal of science education is to produce scientifically literate citizens that are capable of responding to societal impacts of science and live in an increasingly scientific world is the foundation of discourse from both the Gilded Age and today. While modern day scholars utilize the same foundational beliefs as their Gilded Age counterparts, the modern day literature is also much more global and wholistic in scope than that of the Gilded Age.

One significant way that today's discourse is more global and wholistic than that of the Gilded Age is evidenced in how modern day scholars are more inclusive of whom is included and meant to benefit from scientific literacy. The NRC put it succinctly when they write, "The *Standards* apply to all students, regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science."[582] The AAAS begin their *Benchmarks* with the statement that the America's future is one in which "*all* [italics in original] students would become literate in science."[583] Here, scientific literacy for all students truly

[582] *Standards*, 2.
[583] *Benchmarks*, vii.

means *all* students, unlike the Gilded Age definition of "all" which included only white, middle class, Anglo Saxon, Protestant, boys. In fact, Wolff-Michael Roth takes this a step further and maintains that scientific literacy is not a characteristic of individuals, rather it is "an emergent, *collective* [italics in original] phenomenon."[584] For Roth, not only should everyone be scientifically literate but everyone should work together in a collective way to use their scientific literacy in society. Including all groups in scientific literacy truly is a positive development beyond the Gilded Age basis for science education for scientific literacy.

Another way that modern day discourse on scientific literacy has diverged from the Gilded Age discourse is the inclusion of more environmental concerns in the modern day literature. The AAAS documents describe the characteristics of a scientifically literate individual as including an "intelligent respect for nature," familiarity "with the natural world," and recognition of the diversity and unity of the natural world.[585] The NRC *Standards* also recognize such issues, writing that scientific literacy is important because "the collective judgment of our people will determine how we manage shared resources – such as air, water, and national forests."[586] Peter Fensham, for his part, feels that a scientifically literate citizenry is necessary "for a good balance between development and environmental concerns."[587] Avi Hofstein and Robert Yager also demonstrate an environmental-mindedness in their descriptions of scientific literacy. They mention worldwide starvation and degradation of the natural environment as current social problems that require a scientifically literate citizenry.[588] Following suit, Paul DeHart Hurd mentions knowledge and understanding of new energy sources, environmental problems, and the human ecosystem as broader aspects of scientific

[584] "Scientific Literacy," 17.
[585] *SFAA*, xiv, xvii.
[586] *Standards*, 1.
[587] "Science for All," 417.
[588] "Societal Issues."

literacy.[589] Environmental concerns, like the broader inclusion of all students in scientific literacy, is another example of a positive amendment of the notion of scientific literacy. Gilded Age scholars did hold the belief that science education was important in order to create a more socially responsible citizenry that would be able to respond to and deal with societal impacts of science, but, important as their societal issues were (e.g., health and disease, electric machines, and scientific fraud) the notion of environmental concerns, let alone environmental justice, was not considered. By including such questions, the modern day notion of scientific literacy is a positive development beyond that of the Gilded Age.

Another more inclusive aspect of the modern day notion of scientific literacy is the explicit inclusion of technology in the discourse. The AAAS included a section on the nature of technology as one major recommendation for a common core of learning that promotes scientific literacy.[590] Following suit, the NRC includes science and technology as one of their recommended content standards.[591] Thomas Evans, an early advocate of scientific literacy, maintained that "the scientifically literate person is aware of the differences between science and technology, but he also perceives their interrelationships."[592] One of his suggestions for attaining scientific literacy was to explicitly include technology in the curriculum. While Gilded Age scientists may themselves have held accurate beliefs about the differences between science and technology, conclusions presented in Chapter 3, "Functional Education," of this document indicate that the general public as well as many of the scholars examined did not differentiate between science and technology. Modern day literature on scientific literacy is more explicit about the inclusion of technology, making clear and discrete differentiations between science and

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[589] "Scientific Literacy."
[590] *SFAA*; *Benchmarks*.
[591] *Standards*.
[592] "Scientific Literacy," 81.

technology and making sure to incorporate technology concerns into science education. While the differentiation between science and technology may seem punctilious, the fact that modern day scholars make a distinction and take care to include technology as an aspect of scientific literacy shows that the modern day notion of scientific literacy is more comprehensive and elaborate than that of the Gilded Age.

An additional aspect of the modern day notion of scientific literacy that make it more comprehensive than the Gilded Age notion is the inclusion of social justice issues. As noted above, the modern day literature is much more inclusive of all students. More than this though, Margaret Eisenhart, Elizabeth Finkel, and Scott Marion point out that the AAAS has a "commitment to scientific literacy for a more socially compassionate and responsible democracy."[593] In other words, creating scientifically literate citizens who can think for themselves and deal with societal impacts of science is not enough – these citizens should be compassionate human beings who build and protect "a society that is open, decent, and vital."[594] Stuart Lee and Wolff-Michael Roth are also concerned with social justice, arguing for "the existence of a morally justified" scientific literacy. In their research, scientific discourse is inserted into moral discourse, and they feel that such situations "are the key to science participating in a morally just society."[595] Present day scholars like Okhee Lee are interested in the social justice characteristics of the learners themselves, where differences in students' knowledge, worldviews, and information sources are due to ethnicity, socioeconomic status, and gender. Lee argues that if scientific literacy is truly going to include all students, the worldview of the learners must be considered.[596] Including social justice discourse into the scientific literacy

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[593] "Conditions for Scientific Literacy," 263.
[594] AAAS, *SFAA*, xiii.
[595] "Science and the 'Good Citizen'," 407, 417.
[596] "Science Knowledge."

literature is certainly a positive extension of the discourse from the Gilded Age, where social justice concerns were essentially non-existent.

One of the less positive developments seen in the literature between the Gilded Age and the present is the increased attention paid to international economic competition. As noted at the end of Chapter 6, "Scientific Progress," a relatively unnoticed Gilded Age argument for teaching science in the schools was to maintain and improve America's position as a leading nation of the world. While only a handful of Gilded Age scholars touched upon this issue, the modern day literature on scientific literacy is quite different. The AAAS documents such as *SFAA* expound that scientific literacy is a necessary part of developing effective solutions to global problems.[597] While rhetoric like this is positive in that scholars are thinking globally, not all of the modern day rhetoric is so encouraging. Take, for example, the *Standards*, which put global concerns in a less positive way. The NRC document reads as follows, "Other countries are investing heavily to create scientifically and technically literate work forces. To keep pace in global markets, the United States needs to have an equally capable citizenry," and "concerns regarding economic competitiveness stress the central importance of science and mathematics education that will allow us to keep pace with our global competitors."[598] Using competitive rhetoric such as this does not mesh with the Gilded Age rhetoric in a positive way because it makes the needs of business and government, rather than the needs of learners, the basis for deciding educational policy. Jon Miller makes an argument similar to the AAAS and NRC documents, writing that "scientific literacy is an important component of long-term economic growth" and that it helps people "to function effectively in citizenship and consumer roles."[599] Again, the use of economic rhetoric is not a positive expansion of the Gilded Age discourse, as the work of Michael Apple

[597] *SFAA*.
[598] NRC, *Standards*, 1-2, 12.
[599] "Scientific Literacy," v.

demonstrates. In his thoughtful essay, Apple sees the folly in constructing science education reform around the themes of international competition, capital accumulation, and the development of new markets and products, where there is a "growing pressure to make the perceived needs to business and industry into the primary goals of the school."[600] The Gilded Age scholars may have had it right, leaving rhetoric about science education as a tool to improve America's competitiveness to the back burners. By focusing on preparing students for future jobs and workplace issues, documents like the *Standards* seem to be making science education into the vulgar utilitarianism that Gilded Age classicists accused it of being.

Final Thoughts

Lawrence Cremin made a very insightful remark in the introduction to his educational history. He wrote, "what happened in the past century of American educational history was neither inexorable nor foreordained; it was the outcome of the particular combinations of people, politics, and chance that mark all of human history."[601] Burke Aaron Hinsdale, writing during the Gilded Age, said much the same thing. He wrote, "The historical study of education in any country should be wide enough to include such factors as national character, the time-spirit, political institutions, the industrial system, and moral, philosophical, and religious ideas. Education is never a single or unrelated fact, but is always bound up with a great number of other facts."[602] In this historical investigation I have aimed to keep these sentiments in hand, including as much of the ideologies and material realities of the time period as were pertinent to the discourse. It may be wondered why there is no mention of religious responses to the argument to include science in the curriculum. Arguments coming from the religious sector of society have been omitted from this research deliberately. This is not because there were no responses from

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[600] "Educational Reform," 785, 782.
[601] *Metropolitan Experience,* xi.
[602] *Studies in Education*, 315.

religious leaders about teaching science in the schools; in fact, the opposite is true. Some religious leaders actually supported the inclusion of science in the secondary school curriculum, using the reasoning that one would become closer to God by studying his creations and laws of nature.[603] On the other hand, some religious leaders opposed the teaching of science based on the perennial rift between science and religion and the perceived threat to the accepted wisdoms of the Catholic Church.[604] The exploration of religious backlash against the teaching of science would be an entire dissertation unto itself, as this is a topic that has appeared throughout history. It is important to understand that the religious arguments about teaching science in the schools has been omitted from this research because they did not specifically counter or support any of the five main arguments from the Gilded Age that have been explored in this research. Religious discourse both for and against teaching science in the schools was not related to modernizing the curriculum, making educational outcomes more functional, combating scientific and medical fraud, addressing public health concerns, or the progress of science, and this is the primary reason why these arguments have been left out of this research.

Because this is an intellectual history rather than a social history, I have aimed to uncover the drift of educational thought during the Gilded Age without considering any actual reorganizations of curricular policy in the schools. Herbert Spencer attested to the importance of looking at the ideas and beliefs behind educational reform. He felt that intellectual discourse about educational reform was a necessary forerunner to actual educational reform because we need to think logically and rationally about educational ideas, developing guiding principles to prepare the way for actual reform.[605] By doing this intellectual history, I have uncovered much of

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[603] "Most Concerns us to Know."
[604] For example see "Catholic Dogma;" "Church Opposed to Science;" Draper, *Religion and Science*; and Temple, *Religion and Science.*
[605] *Education*.

the rationalization for the reality of educational reform that resulted in the eventual inclusion of science in the secondary school curriculum. As science educators, we are plainly aware of the realities of an educational system in which science plays a large part, and by investigating the discourse of the Gilded Age we can become aware of earliest beliefs and justifications that led to the inclusion of science in the curriculum.

With the publication of *The Culture Demanded by Modern Life*, Edward Livingston Youmans set out to bring together in one place a selection of essays on the teaching of science in the schools, "setting forth the subject in its widest relations."[606] His biographer wrote, "The book, published in the spring of 1867, was received with favour: and there can be no doubt that its contents, in this connected form, were vastly more influential for good than in the separate and narrow fields of their original issue."[607] Youmans published his book at the beginning of the Gilded Age, and this was important because it was an early contribution to the drive by prominent scientists to have science taught in the schools.

My goals for this research were multifaceted. I hoped to show that the arguments laid down in *CDML* generated a shift in thinking about education, and that Youmans, by pulling together the ideas of a variety of scholars, was able to frame a comprehensive view of science education for the first time in the history of education in America. I aimed to place the Gilded Age discourse within the appropriate social, political, and cultural contexts, showing that their reasons for teaching science were shaped by various factors and conditions, allowing me to gain a thorough understanding of the characteristics of scientific literacy held during the Gilded Age. Finally I aimed to demonstrate that the vision of scientific literacy found in *CDML* was a lasting and powerful notion that persists today.

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[606] Fiske, *Edward Livingston Youmans*, 221.
[607] Ibid., 227.

The various arguments put forth in *CDML* may have come from numerous men, men who came from various scientific and educational backgrounds and who had various aims for their discourse. With that said, the five arguments explored in this research were intertwined arguments that ultimately created a comprehensive treatise on including science in the school curriculum. That the scholars included in *CDML* were an appropriately representative sample of Gilded Age thought on the topic is substantiated by other literature from the Gilded Age that corroborates the general threads of argument used in *CDML*. Opposing arguments from the Gilded Age also support the point that the discourse found in *CDML* was extensively discussed by Gilded Age intellectuals. As such, it can be concluded that Edward Livingston Youmans was able to frame a comprehensive view of science education during the Gilded Age, and that this view was a shift in thinking about education, going from a classical curriculum that purported to solely train the mind to a curriculum that included science which could both train the mind and infer useful knowledge and skills at the same time.

Through this research I have arrived at a comprehensive understanding of both the reasons for teaching science and the underlying assumptions about scientific literacy held during the Gilded Age. The five arguments pulled from the literature indicate to us a number of things: they show that Gilded Age scholars first and foremost wanted to update the curriculum, moving beyond the dead languages of Latin and Greek to teach current knowledge that included science; that there was a need to make education more utilitarian, where science could both train the mind and also teach students positive knowledge and skills that they could use in their everyday lives; that scientific and medical fraud was a sufficiently substantial social problem and that many scholars felt that a science education could combat this problem; that public health, hygiene, and sanitation issues were crucial social matters that could be addressed with science education; that the improvement of the medical field could be improved with secondary science education; and that the progress of science itself and ultimately society required a widespread embracing of science education. These arguments, as briefly indicated here and extensively detailed in the preceding chapters, comprise the Gilded Age reasons for including science in the curriculum.

This research has demonstrated that the assumptions underlying many of the arguments detailed in the preceding chapters marked the beginning of a broad conception of scientific literacy. By looking at the Gilded Age literature through the lens of scientific literacy, one finds that the fundamentals of our modern day notion of scientific literacy were laid down by the intellectuals of the Gilded Age. The foundations that are common to most modern day notions of scientific literacy include an understanding of the key concepts and principles of science, the ability to use scientific ways of thinking for individual decisions in one's everyday life, and the ability to use scientific ways of thinking to take an active and responsible part in discussions of scientific issues that affect society.

These very same matters were core assumptions during the Gilded Age too. Understanding the key concepts and principles of science played a part in all five of the Gilded Age arguments. It was an important aspect of modernizing the curriculum, where the argument was to teach the existing state of knowledge, particularly since scientific knowledge had grown immensely since the times of the ancient Greeks and Romans. Having knowledge of the principles of science was also an important facet of making education more functional, where preparation for life in an increasingly scientific world required knowledge of the key concepts of science. It was also a component of the fight against scientific and medical hoaxery, where an understanding of the basic principles of science would help people to debunk hoaxes by themselves, particularly those hoaxes that violated the laws of nature. Furthermore, knowledge of the fundamentals of science, particularly anatomy and physiology, would go a long way in addressing public health and sanitation issues as well as addressing the need to improve the scientific knowledge of physicians. Finally, an understanding of the key concepts and principles of science was a major aspect of teaching science in order for science itself to progress – future scientists needed to learn the basics of science while they were still in secondary school.

The two other fundamental aspects of our modern day notion of scientific literacy (i.e., the ability to use scientific ways of thinking for individual decisions in one's everyday life, and the ability to use scientific ways of thinking to take an active and responsible part in discussions of scientific issues that affect society) were also fundamental aspects of the Gilded Age discourse. Again, these notions can be seen in all five of the Gilded Age arguments. One of the underlying assumptions of the argument to update the curriculum was that a modern democracy required a more egalitarian curriculum; this, of course, included science, and being a responsible member of a democracy involved being able to participate in public discourse on scientific issues. Making decisions about scientific issues in the public agenda was also a fundamental aspect of the argument to make education more functional, where people should have some ability to use scientific ways of thinking to help them make informed decisions about societal impacts of science. This same line of reasoning applied to the argument to teach science to combat scientific and medical fraud, where a scientific habit of mind would help people make their own decisions about scientific and medical claims. It was also important for people to use a scientific habit of thought when participating in public discussions on health, disease, and sanitation, which were important concerns within the argument to teach science in order to address public health issues. Finally, a scientific habit of mind was also an aspect of the argument about scientific progress, where it was important for the public to support science by making informed decisions about the work of scientists.

In conclusion, the ideas expounded by intellectuals in the Gilded Age for including science in the school curriculum were comprehensive and in the forefront of educational reform. Their discourse laid down the foundations of why we teach science in the schools, and present day science educators would do well to understand some of the origins of the discipline. In particular, a modern day topic of the utmost importance such as scientific literacy has foundations in the Gilded Age literature.

The Gilded Age arguments and concerns were consequences of certain Gilded Age circumstances like medical quackery, the advent of incandescent light bulbs, and the use of cesspool-privy vault systems for waste disposal. With that said, the arguments and concerns of the Gilded Age intellectuals are also universal and enduring. For example, teaching people how to think like scientists in their everyday lives in order to respond to societal impacts of science is an enduring argument for teaching science. The need for a scientifically literate citizenry that can participate in a democracy is another enduring legacy of Gilded Age thought. Finally, giving students an understanding of the nature of science (e.g., what it takes to make a scientific claim and the changing nature of scientific knowledge) is another enduring aspect of the Gilded Age discourse. The Gilded Age arguments are also universal because, while they were the product of circumstances and ideologies of that time period, the same arguments can be used to address circumstances and ideologies of the present.

Because much of the Gilded Age literature addresses issues and concerns that are still relevant today, particularly in terms of scientific literacy, it is valuable to understand their discourse and how they rationalized and attempted to solve science education issues. I feel that I have uncovered the principle Gilded Age beliefs and rationales for teaching science. With that said, there is still more research that can be done on this topic. My own research has been constrained in a number of ways: I have only looked at the intellectual discourse of the Gilded Age, not the realities of schooling and curriculum during that time; I have centered the research around those arguments as presented in *CDML*; and I have organized my thinking about the discourse around the five main arguments found in *CDML*. Further research can and should be done in this field. It would be beneficial for someone to do a social history of this time period, looking at what was happening in the schools and in curricular policy in terms of including science in the secondary schools. While there have been any number of educational histories written in the twentieth and twenty-first centuries, none solely focus on the social history of the inclusion of science in the secondary school system, and none focus solely on the Gilded Age. Someone should also look into the debate between scientists and clergymen about teaching science, particularly the heated dialogue that raged after Charles Darwin published his book *On the Origin of Species*.[608] This would shed light on a topic that has not been explored here, namely the backlash against science from the church. Finally, while it may be somewhat repetitive to do so, someone might look at the discourse in *CDML*, organizing their research by looking at each scholar and his essay in order. The problem with organizing my own research around themes rather than following the organization of *CDML* was that a few scholars in *CDML* are completely omitted from this research because their rather brief essays did not touch on any of the five main arguments explored in this research. (Note: The three chapter authors who were excluded are Edouard Seguin, a Gilded Age physician, Edward Forbes, a Gilded Age geologist and paleontologist, and Lord Macaulay, a Gilded Age British poet and politician.) Of course I could have included any number of further arguments made by the Gilded Age scholars for

[608] For example see "Darwin's Mistake;" Gmeiner, "Liberty of Catholics;" and Searle, "Evolution and Darwinism."

including science in the curriculum, but I chose to limit my research to the five most widely cited arguments. Someone may wish to further look at the discourse in *CDML* to uncover some of the more obscure and less influential reasons given for teaching science in the schools.

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APPENDIX A

LITERATURE REVIEW ON SCIENTIFIC LITERACY

The "Party Line" Definition of Scientific Literacy

The current, generally accepted, definition of scientific literacy comes from the American Association for the Advancement of Science [AAAS] and the National Research Council [NRC]. While there is not necessarily consensus amongst science education scholars on the interpretation of what it means to be scientifically literate, the definitions put forth by *SFAA*, the *Benchmarks*, and the *Standards* are often the point of reference for the debate. *SFAA* defines a scientifically literate person as someone who is:

> aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individuals and social purposes.[609]

The *Benchmarks*, a companion to *SFAA* that raises scientific literacy issues closer to the curriculum and instruction, define a scientifically literate person in much the same way as *SFAA*. With these two publications, the AAAS "promotes literacy in science, mathematics, and technology in order to help people live interesting, responsible, and productive lives."[610] The *Standards* give an indication of why scientific literacy should be a goal of science education:

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[609] AAAS, *SFAA*, xvii.
[610] AAAS, *Benchmarks*, xi.

> Scientific literacy enables people to use scientific principles and processes in making personal decisions and to participate in discussions of scientific issues that affect society. A sound grounding in science strengthens many of the skills that people use every day, like solving problems creatively, thinking critically, working cooperatively in teams, using technology effectively, and valuing life-long learning.[611]

Broad, idealistic, and nebulous definitions like these doubtless stoke the fires of dispute about the definition of scientific literacy.

The Debate about Scientific Literacy

As Bybee writes, most science educators now agree that the purpose of school science is to improve the scientific literacy of students.[612] Of course, without an agreed-upon interpretation of scientific literacy, there is much debate about what it means to improve the scientific literacy of our students. As Roberts so eloquently writes, "Promiscuity of usage is a characteristic of educational slogans which have been around for a while."[613]

While an exact interpretation of scientific literacy is under debate, DeBoer acknowledges that a general understanding of science for everyday life, not preparation for scientific careers, is customarily implied by the term.[614] Roth and Calabrese-Barton further illuminate some of the assumptions underlying most uses of the term scientific literacy. They write that discussions of scientific literacy are usually based on three assumptions, namely that "scientific literacy is an attribute of individuals, science is the paradigmatic mode for rational human conduct, and school knowledge is transportable to life after school."[615] Roth and Calabrese-Barton's particular take on scientific literacy will be discussed further below, but they, like DeBoer, remind us that while

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[611] NRC, *Standards*, ix.
[612] Bybee, "Achieving Scientific Literacy."
[613] Roberts, *Scientific Literacy*, 19.
[614] DeBoer, "Scientific Literacy."
[615] Roth and Calabrese-Barton, *Rethinking Scientific Literacy*, 157.

there is debate about what it means, most discourse on scientific literacy is based upon common assumptions. The most recurrent assumption about scientific literacy seen in the literature reviewed here is that science is product, process, and human enterprise.[616]

The assumption that science is product, process, and human endeavor is generally included in a given definition of scientific literacy. Palincsar, Sullivan, Anderson, and David's research suggests that this is true; they found that descriptions of scientific literacy from the 1990s could be characterized in one of three ways: application of scientific knowledge (i.e., process), interpretation of data and production of written text (i.e., product), and promotion of the collaborative social aspect of science (i.e., human enterprise).[617] Miller, who is best known for attempting to assess scientific literacy in adults, established the following as the measures of scientific literacy: an understanding of the processes and methods of science (i.e., process), a basic vocabulary of scientific terms and concepts (i.e., product), and an understanding of the impact of science on society (i.e., human enterprise).[618] Eisenhart, Finkel, and Marion suggest that literacy, whether scientific or otherwise, involves having knowledge (i.e., product), using that knowledge in multiple contexts (i.e., process), and doing so for worthwhile purposes (i.e., human enterprise).[619] Oliver et al. identify three commonly identified aspects of scientific literacy: familiarity with content knowledge (i.e., product), scientific ways of thinking (i.e., process), and its value in building socially responsible and competent citizens in democratic society (i.e., human endeavor).[620]

Even critics of the notion of scientific literacy seem to adopt the common notion that science is product, process, and human enterprise Bauer, a vocal critic of the discourse on

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616 Evans, "Scientific Literacy."
617 Palincsar, Anderson, and David, "Pursuing Scientific Literacy."
618 Miller, "Scientific Literacy."
619 Eisenhart, Finkel, and Marion, "Conditions for Scientific Literacy."
620 Oliver et al., "The Concept of Scientific Literacy."

scientific literacy who has found fault with "almost everything that has been said about the supposedly critical state of scientific illiteracy," does seem to accept that there are three inherent components of scientific literacy. These three things are: the concepts of science (i.e., product), the nature of the scientific activity (i.e., process), and the role of science in society and culture (i.e., human enterprise).[621] While innumerable examples could be given to demonstrate that science as product, process, and human enterprise are included in most discussions of scientific literacy, the above examples should suffice to make the point. What is more interesting is to reveal the nuances in various discussions of scientific literacy, and it is to this that I now turn.

Nuances in Defining Scientific Literacy

Nuances in the various discussions of scientific literacy are more than merely interesting; they can tell us something about the assumptions of the authors, their focus, and their value preferences as regards the goals of science education. Moreover, by getting a feeling for the nuances in current discussions of scientific literacy, I can better interpret the nuances in Gilded Age discussion of similar topics, particularly as the term scientific literacy was not used back then.

Taking a cue from Gabel; Palincsar et al.; Pella, O'Hearn, and Gale; and Roberts, I have attempted to categorize a sample of scholarly papers that discuss scientific literacy.[622] It is outside the scope of this prospectus to look at and categorize every definition and discussion of scientific literacy available; I can, however, look at a relatively representative sample of papers, spanning the years 1958 to 2004, and come to a reasonable understanding of the various nuances

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[621] Bauer, *Scientific Literacy*, 2. Bauer's point seems to be that while these three things may be considered scientific literacy, there is no way to measure them, and thus any discussion that includes these three things is inadequate.
[622] Gabel, "Perceptions of Scientific Literacy;" Palincsar et al., "Pursuing Scientific Literacy;" Pella, O'Hearn, and Gale, "Referents to Scientific Literacy;" and Roberts, *Scientific Literacy*.

in the discourse. As such, approximately thirty-five peer-reviewed papers were used for this purpose.

I have identified five distinct threads or emphases in the literature on scientific literacy, each of which has multiple subsets:

- Social responsibility – Includes science in a democracy; science for decision-making, particularly on controversial socio-scientific issues; science to promote social responsibility; science to stimulate citizenship; the ability to understand scientists and what one reads or hears in the news; the ability to choose one's experts; and the ability to communicate in science
- Interaction of science and society – Includes STS; the use of science in our everyday lives; science as a social activity; and science as a collaborative human endeavor
- Organization of knowledge – Includes understanding the major concepts of science; understanding the processes of science; and learning to use the skills of science
- Progress of science – Includes the promotion of science itself; and the promotion or aid to industry, business, and economics as relates to science
- Social justice – Includes SES, gender, and ethnicity in science

Social Responsibility

This category, while a bit broad, encompasses by far the most frequent reasons given for promoting scientific literacy. This category covers those things that relate to responsible and active citizenship such as being able to understand scientific issues one reads in the media, being able to discuss these issues knowledgeably, and, moreover, being able to make informed democratic decisions about scientific issues. Here, an understanding of the concepts and principles of science is less important that decision-making skills and the ability to participate in a democracy where scientific issues arise. As McGinn and Roth view it, "scientific knowledge as competence in scientific discourses rather than as bodies of facts and theories."[623]

The defining term for this category is arguably "citizen," with expressions such as "effective citizenship," "productive citizens," "informed citizens," "concerned citizens," "good citizenship," and "citizen science" commonly found.[624] The idea that a good citizen is one who can participate in the democratic process seems fundamental to scholars who advocate for scientific literacy based on social responsibility. In fact, Pella writes that unless the public has an understanding of the implications of scientific development on society, the "democratic process is endangered."[625]

While Pella's notion may be a bit over simplistic, most scholars found in this category agree that scientific literacy includes being able to make informed decisions about scientific and technological issues that are in the national public agenda. In other words, scientific literacy involves using decision-making skills for scientific issues.[626] Scientific issues in the public agenda could include things like nuclear power, acid rain, genetic engineering, food and agriculture, drugs, cancer, recycling, sanitation, and pollution, just to name a few.

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[623] McGinn and Roth, "Preparing Students," 19.

[624] Ibid., 17; AAAS, *SFAA,* xiii; and Kolstoe, "Consensus Projects," 645, use the term "citizen." Culliton, "Dismal State," 243; and Miller, "Scientific Literacy," 1, use the term "effective citizenship." Hurd, "Scientific Literacy," 407, uses the term "productive citizen." DeBoer, "Scientific Literacy," 592; and Ewing, Campbell, and Brown, "Improving Student Attitudes," 350, use the term "informed citizens." Eisenhart et al., "Conditions for Scientific Literacy," 285, use the term "concerned citizens." Lee and Roth, "Science and the 'Good Citizen'," 403, use the term "good citizenship." Roth, "Scientific Literacy," 13, uses the term "citizen science."

[625] Pella, "Scientific Literacy," 347.

[626] Hurd, "Scientific Literacy;" Kolstoe, "Consensus Projects;" Lee and Roth, "Science and the 'Good Citizen';" Meehan, "Nuclear Safety;" Miller, "Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.

Part of being able to make informed decisions about scientific issues in the public agenda is being able to understand discussions of these things in the popular media.[627] While Koelsche measured the vocabulary and knowledge of scientific concepts needed to interpret and understand the material in science articles and printed news items, this is not all that is necessary for scientific literacy in this sense. One must be able not only to understand what is printed and heard in the mass media; one must also be able to interpret it, make informed decisions about it, and form relevant, logical, and independent conclusions about it. Furthermore, being able to construct a good argument and understanding what it takes for others to construct convincing arguments is another science skill that plays a part in understanding scientific discourse in the mass media.

What is more important still than being able to understand and interpret scientific discourse in the mass media is being able to evaluate and make critical judgments about science and scientific authority (i.e., "informed skepticism").[628] For example, a scientifically literate person would be able to distinguish between scientific and pseudo-scientific questions. According to *SFAA*, this means being able to combat "dogmatists, flimflam artists, and purveyors of simple solutions to complex problems."[629] For some, the ability to make critical judgments about scientific authority involves knowing when to seek expert advice and where to find access to responsible expert advice.[630] In other words, being able to make critical judgments about science and scientific authority rests more on one's decision-making skills and competency in scientific discourse than on one's knowledge of the facts of science.

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[627] DeBoer, "Scientific Literacy;" Ewing et al., "Improving Student Attitudes;" Glynn and Muth, "Reading and Writing;" Koelsche, "Scientific Literacy;" and Oliver et al., "The Concept of Scientific Literacy."
[628] AAAS, *SFAA*, 186; Kolstoe, "Consensus Projects;" McGinn and Roth, "Preparing Students;" and Shamos, *The Myth of Scientific Literacy*.
[629] AAAS, *SFAA*, xiv.
[630] DeBoer, "Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.

Using one's scientific literacy to influence social activity, such as participating in local community issues like recycling, agriculture practices, or cleaning up pollution is another aspect of scientific literacy as social responsibility. McGinn and Roth call this "science-related activism."[631] Science-related activism is using one's scientific literacy for social responsibility when it involves things like wildlife preservation, drug testing procedures, or the environmental stewardship of a local watershed. Other forms of activism will be discussed under the "social justice" category, where using one's scientific literacy is geared more towards ending social injustices rather than straightforward social responsibility.

Interaction of Science and Society

The interface of science and society is another common thread of discourse on scientific literacy. Shamos calls this "science-based societal issues."[632] The standard argument given for promoting scientific literacy here is for students to be aware of, and be able to respond to, societal impacts of science.[633] Bauer, a critic of the discourse on scientific literacy, declares that rather than making an issue of creating scientifically literate students, we should focus our efforts on helping students to see that science is a human activity.[634] To Bauer, it is better for the student to try to understand science's relationship to society rather than strive for the nebulous concept of scientific literacy.

Lee and Roth; McGinn and Roth; Roth; and Roth and Calabrese-Barton all subscribe to the notion that all science is situated, contingent, and contextual.[635] Their works will be discussed below in the section on scientific literacy for social justice, but they deserve mention

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[631] McGinn and Roth, "Preparing Students," 20.
[632] Shamos, *The Myth of Scientific Literacy*, 77.
[633] Bybee, "Achieving Scientific Literacy;" Culliton, "Dismal State;" Evans, "Scientific Literacy;" Ewing et al., "Improving Student Attitudes;" Hofstein and Yager, "Societal Issues;" Miller, "Scientific Literacy;" and Mitman, Mergendoller, Marchman, and Packer, "Components of Scientific Literacy."
[634] Bauer, *Scientific Literacy*.
[635] Lee and Roth, "Science and the 'Good Citizen';" McGinn and Roth, "Preparing Students;" Roth, "Scientific Literacy;" and Roth and Calabrese Calabrese-Barton, *Rethinking Scientific Literacy*.

here because their fundamental assumption is that science is socially situated, and that the interaction of science and society is the primary motivating factor in promoting scientific literacy.

Along these same lines, several scholars examined for this literature review stress the social nature of science. For example, Palincsar et al. use collaborative problem solving in a middle school classroom to promote scientific literacy, with the notion that science itself is a collaborative, social activity where students, like scientists, work with one another.[636] *SFAA* and the *Standards* both support collaboration in the science classroom. *SFAA* criticizes "the present science textbooks and methods of instruction," which "fail to encourage students to work together, to share ideas and information freely with each other."[637] Similarly, the *Standards* encourage teachers to develop communities of science learners, where collaboration among students is nurtured.

To some, science is more than simply a collaborative and social activity; yes, science is done in a collaborative and social way, but scientific literacy "is an emergent, *collective* phenomenon [italics in the original]."[638] For these scholars, scientific literacy cannot be reduced to a characteristic of an individual, or something that is acquired by a student; scientific literacy is something that emerges from collective situations. Furthermore, scientific activity in the community is part of a larger situation than simple scientific literacy. Trefil seems to feel the same way about scientific literacy, writing that scientific literacy is merely a subset of a more general "cultural literacy" needed to confront social issues.[639] In this case, it would seem that

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[636] Palincsar et al., "Pursuing Scientific Literacy."
[637] AAAS, *SFAA*, xvi.
[638] Lee and Roth, "Science Knowledge;" Roth, "Scientific Literacy," 17; and Roth and Calabrese Calabrese-Barton, *Rethinking Scientific Literacy*.
[639] Trefil, as cited in Oliver et al., "The Concept of Scientific Literacy," 543.

scientific literacy is not necessarily a goal of science education, but rather an outcome of community-based, science-related activism.

This particular thread of discourse on scientific literacy (i.e., the interaction of science and society) is the one where scholars are most apt to discuss the curriculum. A science curriculum that emphasizes the interaction of science and society would be one where real-life problems and current issues are the focus. Examples could include things such as nuclear energy, cell biology, genetic engineering, cancer, wellness, and environmental problems.[640] The activities in a science classroom would be relevant to the everyday lives of the students, and projects would be socially situated, possibly using their own communities as the focus of activities.[641] Science here is socially relevant to the students in the classroom, where the contexts are meaningful to them (i.e., the society in which they live), not students in another state or region where textbooks are written. It seems somewhat safe to assume that the curricula advocated for by those who emphasize the interaction of science and society would be locally generated, focusing on local hands-on activities rather than teaching out of a textbook.

Organization of Knowledge

As noted above, the organization of scientific knowledge includes understanding the process of science, knowledge of the facts and principles of science, and acquiring the skills of science. None of the scholars included in this review would consider the organization of scientific knowledge as the sole purpose or criterion of scientific literacy; rather, the organization of scientific knowledge is merely a necessary component of the scientifically literate person.

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[640] DeBoer, "Scientific Literacy," mentions nuclear energy and cell biology; Hofstein and Yager, "Societal Issues," mention genetic engineering and cancer; and Hurd, "Scientific Literacy," mentions wellness and environmental problems.

[641] Fensham, "Science for All;" Hofstein and Yager, "Societal Issues;" Mitman et al., "Components of Scientific Literacy;" Palincsar et al., "Pursuing Scientific Literacy;" Roberts, *Scientific Literacy*; and Roth and Calabrese Calabrese-Barton, *Rethinking Scientific Literacy*.

Knowledge and understanding of the basic facts and principles of science, such as motion; electromagnetic forces; cell structure; the action of wind, waves, and water; and the building blocks of matter like carbon, oxygen, and nitrogen, would seem to be a rather essential facet of scientific literacy. Likewise, a knowledge and understanding of the basic vocabulary of science (e.g., cardiovascular, centigrade, genetic, nucleus, rotation, and thermostat, to name a few), seems an equally fundamental facet of scientific literacy.[642] This seemingly obvious aspect of scientific literacy is explicitly addressed in *SFAA*, the *Benchmarks*, and the *Standards*. As for the thirty-plus scholarly articles examined for this literature review, only five even mention a knowledge and understanding of the facts, principles, or vocabulary of science.[643]

Acquiring the skills of science is more commonly addressed in the literature. Scientific skills, as I see it, can be classified into two different sorts: manual or sensory skills, and habits of thought (better known to some as critical thinking skills). *SFAA*, the *Benchmarks*, and the *Standards* all address the first type, writing that scientific literacy includes being able to observe, measure, conduct experiments, and use the appropriate scientific tools. Included in this category would be skills of science such as using a balance, using a graduated cylinder, drawing a graph or histogram, and writing up a lab report. The second type of scientific skills, scientific habits of though, or scientific ways of thinking, are more common themes found in the literature reviewed here. These skills include such things as analyzing, interpreting, classifying, predicting, controlling variables, and using both deductive and inductive reasoning. Acquiring these various scientific ways of thinking will encourage students to become independent and logical thinkers

[642] Thanks to Koelsche, "Scientific Literacy" for a list of vocabulary words typically found in mass media. His abbreviated list of vocabulary terms can be found in the article, and a complete list of 693 words gathered from thousands of newspaper and magazine articles can, supposedly, be obtained from the author. Since, however, it is hard to determine whether or not Koelsche is still living and active in science education, this may be somewhat of a pipedream. He did, however, write this article while a professor of science education at UGA, so some remnant may still remain of his research somewhere there.
[643] Bybee, "Achieving Scientific Literacy;" Fensham, "Science for All;" Koelsche, "Scientific Literacy;" Miller, "Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.

who are good at problem-solving.[644] It would seem that for those educators and policy-makers who believe that the purpose of all education is to teach students how to think, this aspect of scientific literacy would hold the most weight, since this category, to a greater extent than any other in this literature review, would teach students critical thinking skills.

To some, acquiring the skills of science means more than acquiring scientific habits of mind. For example, there are personality traits that are necessary in science, including things like honesty, open-mindedness, curiosity, skepticism, and the ability to identify one's assumptions.[645] Science education programs that attempt to instill the processes and procedures of science in their students would do well to consider these character traits as part of the program as well, in order to deepen the scientific literacy of their students.

Bybee, Collins, and Hurd all use the term "inquiry" in their discussion of scientific literacy.[646] Inquiry involves the processes of science such as observing, comparing, hypothesizing, the ability to ask questions, conduct investigations using appropriate tools and techniques, construct explanations, and communicate arguments. While these things are surely the processes and procedures of science, and thus are a part of the organization of scientific knowledge, inquiry is such a hot topic in science education these days that it deserves mention on its own. Science as inquiry is a major facet of *SFAA*, the *Benchmarks*, and the *Standards*. Given the many sides of scientific literacy, all of which are valid reasons to advocate for scientific literacy, it would seem that science as inquiry fulfills only a very small part of scientific literacy.

[644] Fensham, "Science for All;" Glynn and Muth, "Reading and Writing;" Koelsche, "Scientific Literacy;" Palincsar et al., "Pursuing Scientific Literacy;" and Shamos, *The Myth of Scientific Literacy*.
[645] AAAS, *SFAA*; *Benchmarks*; Fensham, "Science for All;" and NRC, *Standards*.
[646] Bybee, "Achieving Scientific Literacy;" Collins, "Looking Backward and Forward;" and Hurd, "Science Literacy."

Progress of Science

This particular nuance within the discourse on scientific literacy is somewhat like that of the organization of knowledge described above - none of the scholars included in this review would consider the progress of science itself as the sole purpose or criterion of scientific literacy; rather, the progress of science is a minor aspect of a science education that advances scientific literacy.

Hurd, who, in 1958, was one of the first to talk about scientific literacy, wrote that scientific literacy was necessary in order to "prepare young people for the approaching era of world industrialization" and to meet "the challenges of an emerging scientific revolution."[647] In this case, the progress of science is not the goal of science education, but it is the instigator for achieving scientific literacy.

Some more recent discourse paints a more interesting link between the progress of science and scientific literacy. DeBoer, the *Standards*, and Miller all claim that scientific literacy will benefit the workforce, helping students to "hold meaningful and productive jobs in the future."[648] The *Standards* even maintain that scientific literacy is necessary for the United States to maintain its economic competitiveness, keeping pace with global competitors. Culliton echoes this sentiment, writing that scientific literacy is necessary for long-term economic growth.[649] Apple seems to disagree, writing that science education (or rather, any education at all) that is based on capital accumulation or international competition is misguided.[650] Interestingly, Miller suggests that scientific literacy is essential for both making students function as effective citizens

[647] Hurd, "Science Literacy," 14.
[648] DeBoer, "Scientific Literacy;" NRC, *Standards*, 12; and Miller, "Scientific Literacy."
[649] Culliton, "Dismal State."
[650] Apple, "Educational Reform."

(as discussed earlier) and also to function effectively in their role as consumers.[651] Apple sees the folly here too, writing that it is madness to "make the perceived needs of business and industry into the primary goals of the school."[652] It should, of course, be remembered that neither the *Standards*, nor DeBoer, nor Culliton, nor Miller put all of their eggs in the "scientific literacy to improve our economic competitiveness" basket, and Apple's remarks are not directed at these scholars. It is, however, worth noting that improving our economic competitiveness, keeping pace with our capital accumulation, and producing effective consumers *does* seem to be a part, if only a small one, of scientific literacy.

Finally, the progress of science itself is an aspect of some of the discourse on scientific literacy. Pella writes, "It is obvious that a society that has evolved to its present level due to science … must be literate in science."[653] In other words, if science itself is to progress, both scientists and the community as a whole must be scientifically literate. For Fensham, "the evolution of scientific knowledge" is one of many valid aspects of a science education that promotes scientific literacy.[654] It is interesting to note that Fensham uses the phrase "science for all" as the slogan for a scientifically literate citizenry; under this phrasing, Fensham's sentiment can be seen to be quite similar to Pella's – the progress of science depends on both scientists and the lay citizenry being scientifically literate.

Social Justice

Scientific literacy for social justice is a different nuance than scientific literacy for social responsibility. Whereas scientific literacy for social responsibility emphasizes using one's scientific literacy for democratic purposes, to be an effective citizen, to understand and engage in

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[651] Miller, *Scientific Literacy*.
[652] Apple, "Educational Reform," 782.
[653] Pella, "Scientific Literacy," 348.
[654] Fensham, "Science for All," 427.

discourse on scientific issues in the public agenda, and make informed decisions on these issues, scientific literacy for social justice is something quite different. Those who see scientific literacy as a means towards social justice see science teaching as a political act. When scientific literacy is seen through a social justice lens, sociopolitical terms frame science education.[655] Roth and Calabrese-Barton see scientific literacy as a political endeavor oriented to bring about social change, where "teaching is a political act when it promotes active participation in citizen science and engagement for social justice." They also write that "scientific literacy is promoted when we view science as and for participation in the necessarily political life of the community."[656] In other words, scientific literacy for social justice takes scientific literacy for social responsibility to a political level.

Those who view scientific literacy through a social justice lens see more than just political activism though. Scientific literacy itself can be a social justice issue when the characteristics of the learner are taken into account. A critical feminist interpretive framework for viewing scientific literacy, such as Atwater's, looks at the social, political, cultural, economic, ethnic, and gender values of the learner and of science itself.[657] Lee, and McGinn and Roth look at the ethnicity, SES, and gender of science learners and emphasize the diverse range of communities and locations where science is created and used.[658] Eisenhart et al. look at scientific literacy through a social justice lens when they urge the involvement of more and diverse people in science.[659]

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[655] Lee and Roth, "Science and the 'Good Citizen';" and Roth and Calabrese Calabrese-Barton, *Rethinking Scientific Literacy.*
[656] Roth and Calabrese Calabrese-Barton, *Rethinking Scientific Literacy*, 214, 158.
[657] Atwater, "Critical Feminist Interpretive Framework."
[658] Lee, "Science Knowledge;" and McGinn and Roth, "Preparing Students."
[659] Eisenhart et al., "Creating the Conditions."

Furthermore, scientific literacy can be viewed through a social justice lens when the worldview of the learner is taken into account. Lee stresses the various ways of knowing, thinking, and communicating that come in to play in the science classroom. A learner's prior knowledge, their belief systems, their cultural background, and their social background are all factors involved in learning, and thus achieving scientific literacy.[660] In one example, the worldview of the learner may be incompatible with the worldview of science, thus causing potential problems in achieving scientific literacy. As can be seen, scientific literacy as a social justice issue can involve either using one's scientific literacy for social or political activism or using social justice as the lens through which the researcher investigates scientific literacy.

Influential Factors

There are a variety of factors that influence scholars as they think about scientific literacy. Responding to publications of the AAAS, NRC, NSF, or National Science Teachers Association (NSTA) is one such factor. Collins writes that publications such as the *Standards*, *A Nation at Risk, SFAA, Benchmarks,* and the Scope, Sequence, and Coordination (SS&C) project of the NSTA provided an opportunity for educators and policy-makers to think about the national vision of scientific literacy.[661] Bybee and DeBoer address three different goals of scientific literacy made by the NSTA and the *Standards*: knowledge goals, method goals, and societal applications goals (these are similar to science as product, process, and human endeavor, as described above).[662] Bybee and DeBoer choose to structure their historical essay on the goals of science education around these themes, showing that their influence came from national science education publications. This should come as no surprise, as their essay appears in a publication supported by the NSTA.

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660 Lee, "Science Knowledge."
661 Collins, "Looking Backward and Forward."
662 Bybee and DeBoer, "Goals for the Science Curriculum."

For a scholar like Lee, publications such as *SFAA* and the *Standards* are a negative influential factor in thinking about science education. What I mean here is that she raises the point that the AAAS and the NRC base their work on the traditional worldview of Western science, which may not be compatible with the worldview of students.[663] Lee frames her discourse on scientific literacy from the point of view of ethnicity, SES, gender, and worldview as a way to address the rhetoric of *SFAA* and the *Standards*. Eisenhart et al. also seem to use national science education reform documents as a negative starting point for thinking about scientific literacy. They begin their "re-examination" of scientific literacy by exploring the way scientific literacy has been defined by the AAAS, the NRC, and NSTA (i.e., Project 2061, *SFAA*, SS&C, the *Standards*, and *Benchmarks*).[664] Their re-examination of scientific literacy argues that the vision of the AAAS, NRC, and NSTA is being implemented narrowly, and while their opinion on scientific literacy is not the issue here, their article does point to the fact that national science education reform documents are a common influential factor in discourse on scientific literacy.

DeBoer reminds us that some scholars are influenced by general standards-based reform and high-stakes testing.[665] Scholars may be induced to think about scientific literacy in terms of how it fits in with today's culture of high-stakes testing. In this case, the influential factor may not be national publications about science education but rather publications designed for general education. Furthermore, some scholars are influenced not necessarily by documents put out by the AAAS and other such agencies, but rather they are influenced by projects and programs of national agencies. For example, Evans was influenced by the general increase in federal support,

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[663] Lee, "Science Knowledge."
[664] Eisenhart et al., "Conditions for Scientific Literacy," 261.
[665] DeBoer, "Scientific Literacy." This is not to say that DeBoer himself was responding only to high-stakes testing or standards-based reform, only that his article brings these things up.

funding, and loans that became available to support the teaching of science and mathematics in the 1960s. This "increased federal support" influenced Evans to rethink scientific literacy.[666] Evans does not give any specifics of the federal support and funding that he talks of, but one can assume (since he published in 1970 and mentions the impact of Sputnik on science education) that he means the so-called alphabet curricula of the late 1950s and 1960s such as SCIS, PCCS, BSCS, CBA, IPS, and SAPA, to name a few. Walsh also seems to have been influenced by national support and funding in his discussion of scientific literacy. He mentions the squeeze on funding from the NSF in the 1970s, the drastic budget cuts of the Reagan Administration, and the then-new (i.e., 1988) rebirth of NSF funding for education.[667] While Walsh's article reads like a laundry list of budget and director changes at the NSF over the years, he does remind us that funding (or lack thereof) from national agencies may help spur on (or taper off) discourse on topics such as scientific literacy. It would be interesting to note if the frequency in discourse on scientific literacy is higher during periods of greater funding from agencies like the NSF.

Economics, above and beyond mere funding by national agencies, is another influential factor in discourse on scientific literacy. As mentioned earlier, Apple is concerned with the growing pressure to turn business and industry needs into the needs of education.[668] He addresses things such as international competition and capital accumulation as negative influences for educational reform, and he uses the resulting educational crisis to rethink scientific literacy amongst other things. McGinn and Roth also acknowledge the influence of funding agencies, political pressure, and lobbyists on educational reform.[669] As discussed earlier, McGinn and Roth frame their interpretation of scientific literacy as social responsibility and social justice; this

[666] Evans, "Scientific Literacy," 80.
[667] Walsh, "Breakthrough for Education."
[668] Apple, "Educational Reform."
[669] McGinn and Roth, "Preparing Students."

shows that they themselves are influenced by politics. Culliton and Walsh, on the other hand, both look at scientific literacy through an economic lens in a positive way.[670] They both seem to think that economic competitiveness, especially American competitiveness in the international marketplace, is a positive starting point for looking at scientific literacy. In other words, American economic competitiveness can help initiate strong public support for science education and scientific literacy.

Sometimes discourse on scientific literacy is influenced by the general rate of change in science, or more particularly, when the impact of science on society is progressing rapidly. Scholars such as Bybee and DeBoer; DeBoer; Hughey and Stevens; and Hurd all seem to be influenced by the rapid (sometimes "startling") rate of scientific change.[671] Whether or not the rate of scientific change is rapid or not, scientific change that affects society and/or everyday life is often an influential factor in thinking about scientific literacy. The following are just some scientific issues (in no particular order of importance) that have influenced scholars to reflect on scientific literacy: nuclear energy, space exploration, cell biology, brain physiology, September 11th, Sputnik, pesticides, drugs, rockets and missiles, birth control, environmental awareness and concern, acid rain, the ozone layer, genetic engineering, health and disease, and the energy crisis.[672]

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[670] Culliton, "The Dismal State;" and Walsh, "Breakthrough for Education."
[671] Bybee and DeBoer, "Goals for the Science Curriculum;" DeBoer, "Scientific Literacy," 586; Hughey and Stevens, "Scientific Literacy Concerns;" Hurd, "Science Literacy;" and Hurd, "Scientific Literacy."
[672] Hofstein and Yager, "Societal Issues;" Meehan, "Nuclear Safety;" and Miller, *Scientific Literacy*, all cite nuclear energy. DeBoer, "Scientific Literacy," cites space exploration, cell biology, and brain physiology. Roth, "Scientific Literacy," cites September 11th. Hurd, "Science Literacy;" and Evans, "Scientific Literacy," cite Sputnik. Hurd, "Science Literacy," cites pesticides and drugs. Hurd, "Science Literacy;" and Roth, "Scientific Literacy," cite rockets and missiles. Bybee and DeBoer, "Goals for the Science Curriculum," cite birth control, and environmental awareness and concern. Miller, *Scientific Literacy*, cites acid rain and the ozone layer. Miller, *Scientific Literacy*; and Roth, "Scientific Literacy," cite genetic engineering. Hofstein and Yager, "Societal Issues;" and Hurd, "Scientific Literacy," cite health and disease. Hofstein and Yager, "Societal Issues," cite the energy crisis. This is not to necessarily say that these particular authors were personally influenced by these specific issues, merely that they cite these issues as possible influences for thinking about scientific literacy.

In a bit of a side note, Shamos mentions one of the more peculiar influential factors for thinking about scientific literacy. Shamos is a well-known critic of the national view of scientific literacy, and in his chapter on the scientific literacy movement he mentions the "self-justification and perpetuation of the science and science education professions."[673] While I am not suggesting that Shamos' only influence is the deceitful university science department, he does seem to have some grievance with the desire of scientists (and science educators) to ensure a steady supply of "future scientists and science-related professionals, including, of course, science educators."[674] This grievance seems to have influenced Shamos' discussion of scientific literacy, at least in part.

Finally, scholars' discourse on scientific literacy is often influenced by their other interests in science education or educational research. For example, Atwater lists "Socio-Cultural-Political Influences on Science Learning and Teaching; and Multicultural Science Teacher Education" as two of her main research interests.[675] Her article framing scientific literacy within a critical feminist interpretive framework is in keeping with her general interest in socio-cultural-political issues.[676] Similarly, Lee places scientific literacy within social and cultural contexts. The social justice implications of her research on scientific literacy are in keeping with other research she has done using social justice and multicultural frameworks.[677] Eisenhart et al. define a number of constructivist theories that might frame a scholar's thinking about scientific literacy (or any number of educational topics for that matter): Piagetian

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[673] Shamos, *The Myth of Scientific Literacy*, 74.
[674] Ibid., 73.
[675] This information was gathered from Atwater's faculty profile on the University of Georgia website: http://www.coe.uga.edu/mse/faculty/atwater/index.html.
[676] Atwater, "Critical Feminist Interpretive Framework."
[677] Lee, "Science Knowledge." Lee's curriculum vitae can be downloaded from the University of Miami website: http://www.education.miami.edu/FacultyStaff/faculty_bio.asp?ID=35#. A perusal of this document should make my point.

constructivism, radical constructivism, and sociohistorical constructivism.[678] It is outside the scope of this literature review (and the topic of scientific literacy) to delve into the various meanings of these different forms of constructivism; my point here is that constructivism, or any other epistemology or pedagogy, may be an influential factor in a scholar's interpretation of scientific literacy.

As can be seen, educators and scholars have yet to come to a consensus about the meaning of scientific literacy. (It would be a whole different discussion to note that there is also no consensus about how to implement and achieve scientific literacy.) Scientific literacy can mean everything from using the skills of science to conduct investigations, to understanding the language and discourse of science in the popular media, to using one's knowledge and understanding of science to make informed decisions in a democracy, to using one's knowledge and understanding of science to affect social or political change. Furthermore, it may be that a consensus on the meaning of scientific literacy stems from the abundance of factors that influence those scholars who discuss scientific literacy. From responding to AAAS and NRC publications such as *SFAA* and the *Standards*, to responding to federal funding (or lack thereof), to responding to scientific issues affecting our lives (e.g., acid rain, bioengineering, and the energy crisis), the host of factors that may influence someone to examine and attempt to define scientific literacy surely plays a part in the innumerable interpretations of scientific literacy out there.

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[678] Eisenhart et al., "Conditions for Scientific Literacy."

APPENDIX B

METHODOLOGY

Historical Research in Education

There is value in looking at modern day issues through an historical lens - an historical understanding can help us make meaning of the present, it can help educators think critically about policy, and it can help educators revise the curriculum. Additionally, finding historical questions embedded in today's educational conflicts can give us insight into contemporary educational reform and raise questions about our assumptions.[679] Thayer-Bacon and Moyer assert that all educational researchers could benefit from reflecting on how an historical perspective can inform their own work.[680] An historical perspective can have value for science teacher educators, science teachers, students, parents, administrators, and policymakers. Furthermore, historical research can add to our knowledge of an existing body of historical knowledge, extend our knowledge of our discipline, modify or correct our understanding of our discipline, or verify certain interpretations of our discipline (whether our discipline is science education or otherwise).[681]

Additionally, historical research can demonstrate that each time period has its own unique circumstances, and that the success of educational practices is contextual and responsive to specific circumstances. This may seem a contradictory statement to the discussion above; if each time period is contextual and therefore cannot give us conclusions about educational

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679 Thayer-Bacon and Moyer, "Philosophical and Historical Research;" Donato and Lazerson, "New Directions;" and Rousmaniere, "Historical Research."
680 Thayer-Bacon and Moyer, "Philosophical and Historical Research."
681 Donato and Lazerson, "New Directions;" and Bybee, "Historical Research."

practice today, how can historical research give us insight into current educational practices or reform, and how can it help us make meaning of the present? Donato and Lazerson help resolve this difficulty by writing that educational historians have to be careful to strike a balance between speaking about the past and the present, and that history is a way of thinking about, understanding, and writing about the themes of education.[682] Educational historians, unlike their history-discipline counterparts, *want* to make connections between the past and present. It is important for both educational researchers and their audience to understand that historical research does not give us answers to today's questions, nor does it give us a roadmap to follow to resolve today's educational problems. What historical research can do is give us something to compare our situation today with, where we can look at the context of today and that of the study period, drawing parallels if necessary, and learn how our predecessors answered educational questions and see if their answers can help us answer similar questions today.

Historical Methodology

It should be noted with some emphasis that historical research is not merely the accumulation of facts concerning people, events, or movements of the past. As Bybee notes, historical facts "have little meaning until they are arranged in some order and presented in a manner demonstrating their significance."[683] In other words, the purpose of historical research is to analyze and interpret the meaning of historical facts (or, in this case, historical documents). Howell and Prevenier remind their readers that our interpretation of the past is bound by those sources available to us, for "the sources left by the people who then lived constructed their reality and construct for the historian today all of their reality he can know."[684] What Howell and Prevenier are saying is that historical interpretation is bounded by the facts, and that we should

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[682] Donato and Lazerson, "New Directions."
[683] Bybee, "Historical Research," 4.
[684] Howell and Prevenier, *From Reliable Sources*, 150.

not read too much into historical documents. We cannot read the minds (only the writings) of authors and therefore should not twist the material to suit our own needs.

The historical researcher assumes that variables are complex and interwoven, and that the purpose of research is contextualization, understanding, and interpretation, not causal explanation or prediction.[685] Rousmaniere reminds us that there is not one correct or true historical interpretation out there; while the purpose of historical research may be to interpret historical facts, the researcher's choice of sources gives rise to their interpretation.[686] In my case, my interpretation of Gilded Age notions of scientific literacy might be vastly different if I were to use documents about course availability instead of intellectual discourse. Using official school documents as my data might lead me to believe that scientific literacy was not an issue at all during the Gilded Age, while using scholarly literature might lead be to believe the exact opposite. It is possible that school documents showing courses offered, and even the content of the courses, may not reveal any indication of scientific literacy such as using science to teach skills like solving problems creatively, thinking critically, working cooperatively in teams, using scientific principles and processes in making personal decisions, and participating in discussions of scientific issues that affect society. Scholarly literature, on the other hand, does show that scientific literacy (although not called by that term) *was* an issue during the Gilded Age.

Intellectual History

There are four broad categories of history: intellectual history, political history, social history, and cultural history.[687] Not everyone, however, would agree that there are only four categories. In fact, Wickberg argues that there are not even distinct boundaries between

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[685] Glesne, *Becoming Qualitative Researchers*.
[686] Rousmaniere, "Historical Research."
[687] Ibid. This categorization is, apparently, open to some debate but will suffice for my purposes here.

intellectual, social, and cultural history.[688] With that said, most types of history could fall within one of these four categories (e.g., constitutional and legal history are political history; economic history, labor history, and religious history could all be considered cultural history; and women's history, African-American history, and immigration history could all be considered social history). For my purposes here though, the categorization of historical research is not the issue; rather, noting and understanding some of the defining characteristics of intellectual history is the issue at hand.

Intellectual history is the history of ideas or thought; it is a study of the development of intellectual patterns of thought, theories, or ideologies over time.[689] In other words, intellectual history is a history (or an interpretation) of meaning – what people meant when they wrote or said things. The research questions of an intellectual history are typically concerned with the development of ideas, which is in contrast to other types of histories which ask questions about things such as government policy, the experience of certain social groups, or forces of culture such as labor organizations. Intellectual history data sources mainly come from formal, institutional sources or the writings of prominent scholars. This is in contrast to other types of histories, which may draw on oral histories, diaries, letters, local newspapers, government documents, census data, and other such sources.

Types of Sources

An historian is concerned, methodologically, with the sources or historical data available to them and the interpretation of these sources. Sources are either primary or secondary, where primary sources are documents created by an authoritative source (i.e., one with direct personal knowledge of the topic) at roughly the time being studied, and they are not filtered through

[688] Wickberg, "Intellectual History."
[689] Rousmaniere, "Historical Research;" and Wickburg, "Intellectual History."

interpretation or evaluation. Secondary sources cite, comment upon, or build upon primary sources. Historians universally agree that primary sources are preferable to secondary ones.

There are a number of ways to categorize primary sources. For example, Howell and Prevenier distinguish between direct and indirect sources. Direct sources are, as the name implies, direct evidence of the topic under study; this could include things like letters, laws, poems, or, in my case, published scholarly articles, published books, and published speeches. Indirect sources are primary in that they were produced during the study period, but they give only indirect evidence of the topic under study; things like inventories, catalogs, sales ledgers, etc. may help the historian to deduce something about the time period or topic under study.[690] In the case of my research, I envision using direct sources; an indirect source on the topic of Gilded Age discourse on scientific literacy may be something like a sales receipt showing that one scholar bought (and presumably read) the work of another scholar, or a party invitation list which may show that two or more of the scholars were personal acquaintances. These hypothetical sources, if they do exist, would presumably not shed as much light onto my particular research topic as the direct sources of published discourse.

Howell and Prevenier outline the three types of written historical sources: social, diplomatic or juridical, and narrative or literary. Social documents, usually found in archives, are the products of the record keeping of bureaucracies, states, charities, foundations, churches, and schools, amongst other institutions. They could include things like accounts of meetings, policies, administrative structures, and registers of people or events. Diplomatic or juridical documents, also typically found in archives, either document a legal situation or create one (e.g., the passing of a law). Narrative or literary documents, usually found in libraries, are things like newspaper articles, scientific articles, dairies, novels, films, biographies, memoirs, and other

[690] Howell and Prevenier, *From Reliable Sources.*

such documents.[691] As I see the difference between literary and narrative sources, literary sources are works of literature such as novels and poems, while narrative sources are all other written sources that are not political or the product of the record keeping of public institutions. I envision that I will use narrative sources for my research.

Brundage categorizes primary sources as either manuscript sources or published sources. Manuscript sources are handwritten or typewritten documents that were not printed, such as notes for a speech or a diary; these documents were intended to be private, or at least for restricted use. Published sources, on the other hand, are material that from the outset was intended to be published and made public; these sources include things like newspapers, autobiographies, company reports, census data, magazines, literary works, and letters and diaries that were published after the author's death.[692] My research will incorporate both types of primary sources, although published sources will make up the bulk of the data. Specifically, scholarly articles published in periodicals and newspapers, along with published books, will constitute the main body of data. As for manuscript sources, the personal papers of some of the scholars will be examined in order to shed additional light on the topic and the discourse. Personal correspondences of Youmans can be found in his biography;[693] personal papers of Huxley, Spencer, Tyndall, and Whewell can all be found at the American Philosophical Society (APS) Library in Philadelphia; those of Fiske can be found at UCLA; those of Eliot at Harvard University; further personal papers of Spencer can be found at the University of London; and further personal papers of Whewell can be found at Cambridge University.

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[691] Ibid.
[692] Brundage, *Going to the Sources.*
[693] Fiske, *Edward Livingston Youmans*.

Locating Source

It is unrealistic to assume that the historian will uncover all the important published and unpublished materials relating to the topic of study. Instead the researcher's goal should be to find the best data (i.e., select the essential and discard the irrelevant) and use it to support their interpretation of history.[694] It is unrealistic to assume that I can acquire and evaluate all of the personal papers of the men mentioned above, so it may be that those scholars whose papers are available from the APS may be the most attainable. Likewise, it is unrealistic to assume that I can uncover every scholarly work that touches upon the topic of scientific literacy or teaching science in the schools. With that said, the discussion below will give some insight into how I plan to go about collecting historical data.

Primary sources themselves are a place to find other primary sources. For example, the scholars whose lectures appear in *CDML* have potential primary sources of their own. Looking at the multitude of things Whewell wrote may uncover even more useful discourse than the one address printed in *CDML.* Similarly, contemporaries mentioned in an intellectual's argument might be a potential source. For example, in *A Century of Science,* John Fiske mentions the lectures of John William Draper.[695] Draper's lectures and other writings are a worthwhile primary source to pursue.

The discourse of various intellectuals will constitue the majority of primary sources. Besides those scholars included in *CDML*, other intellectuals studied will be scientists, educational reformers, university presidents, university professors, educational administrators, doctors, and others who advocated including science in the school curriculum. Intellectuals who campaigned against the inclusion of science in the schols will also be examined in order to

[694] Bybee, "Historical Research;" and Tuchmann, *Practicing History*.
[695] Fiske, *A Century of Science*.

counter the pro-science argument; for the most part, these individuals were classicists who felt threatened by the inclusion of science into the curriculum, which had traditionally feartured Latin and Greek. Religious leaders who felt threatened by the teaching of science may also play a part in the counterargument section. Types of primary sources I will use include university addresses, commencement addresses, journal articles, books, memoirs, compendia of lectures or essays, newspaper articles, and proceedings of association meetings, to name a few.

Journals published during the study period that will be more fully explored include American Association for the Advancement of Science Proceedings; American Journal of Education; American Journal of Science; Appleton's Journal of Literature, Science, and Arts; Lippincott's Magazine of Popular Literature and Science; National Education Association Proceedings; New Princeton Review; North American Review; Popular Science Monthly; School Review; Science; Scientific American; and Sillman's Journal (a.k.a. American Journal of Arts and Sciences). This list is, of course not exhaustive, as presumably more sources will manifest themselves as my research progresses.

Newspapers published during the study period that will be more fully explored include: The Atlanta Constitution; The Chicago Tribune; The Denver Republican; The New York Times; The Wall Street Journal; and The Washington Post. The search will also include other regional or topical (e.g., political) newspapers.

Finally, word of mouth will play a part in the collection of primary sources. For example, a book like Adams' *The Education of Henry Adams* might not necessarily be a natural choice for a study on Gilded Age intellectual discourse on science education. Adams' memoir is more usually known for his literary style, interpretation of politics, and accounts of international relations and politics; he devoted only a small part of the book to science, so it is easy to overlook. Word of mouth led me to this particular book, and its place in the research will be useful because of his point of view on education.[696]

Consideration of Sources

Historians, as with any other type of researcher, aim to use only reliable and valid data. Howell and Prevenier, however, admit that "historians are prisoners of sources that can never be made fully reliable."[697] The validity and authenticity of primary sources can be determined by thinking about certain aspects of the sources. For example, the researcher should ask what the original purpose was for writing the document, or what function the document was originally intended to serve.[698] Some documents, such as *CDML*, were originally intended to influence public opinion.

Howell and Prevenier give something of a checklist for thinking about press documents (e.g., newspaper articles). They write that the researcher should consider the following aspects of the document: content of the text, the author, the publisher, the location of the publisher, the intended audience of the publication, and the context of the publication (e.g., political, social, and economic).[699] While this particular list focuses on press articles, I think that Howell and Prevenier's considerations are worthwhile for most historical documents. The historical context in which it was produced should be a consideration for all historical documents. Events that preceded and followed a document's publication will help to place the document within the correct context. In the case of an intellectual history, the ideas (or patterns of though, theory, or ideology) that preceded and followed the writing of a document are an important consideration.

[696] Thanks to Dr. Oliver for leading me to this book.
[697] Howell and Prevenier, *From Reliable Sources*, 3.
[698] Ibid.; and Brundage, *Going to the Sources.*
[699] Howell and Prevenier, *From Reliable Sources.*

Because my research is an intellectual history, I do not foresee the reliability and authenticity of documents posing quite as much of a problem as it does for other types of history. What I mean here is that the question of whether or not a document is what it is supposed to be is not quite as pressing of a point in my research. Public lectures were *supposed* to be public and influence opinion; scholarly articles in newspapers, journals, or scientific publications were also supposed to be public documents that informed the public, gave the author's opinion on a certain topic, or attempted to influence public opinion on the topic. Publications like *CDML* were intended to collect together certain lectures so that people could read lectures they were not able to attend or read a compilation of essays on one topic. Men like Youmans specifically chose and disregarded lectures and essays according to the theme of the collection – in other words, Youmans was not being subversive by choosing those lectures and essays that he did, for he intended to compile essays on teaching science in the schools. My point here is that scholars who had their works published *meant* to have them published, they were not deceitful in their intentions, and the historical documents that remain today are authentic and reliable in that they are accurate records of what was published during the study period.[700]

The Historical Argument

An historical argument is, essentially, the historian's "results."[701] As noted above, history is more than the accumulation of facts concerning people, events, or movements of the past. In order to move beyond a mere chronology of facts, the historian must state their thesis, or present their results. An historical argument should be argued carefully and tentatively, given the limits of any historical study such as data/sources not found, an incomplete synthesis of facts, and the

[700] It may be worthwhile to note here that just because a man published an idea, it does not necessarily mean that he held firmly to that idea his whole life. I cannot read a dead man's mind, only the written works that survive him.
[701] Rousmaniere, "Historical Research," 44.

subjective decisions of the researcher.[702] In may case, my research questions will guide my research, my analysis of the sources, and the composition of my historical argument. More specifically, my historical argument, or my "results," will involve showing that Youmans, by pulling together the ideas of a variety of scholars, was able to frame a comprehensive view of science education, that *CDML* was a seminal work that enshrined a lasting and powerful notion of scientific literacy as a way of achieving the goals of education, and that the notion of scientific literacy (and how it can achieve the goals of education) established in *CDML* persists today.

In terms of composing an historical argument, "theory provides the explanatory category in which historians expand their initial question into an argument."[703] The theory an historian chooses to work with may be neorevisionist, feminist, or psychoanalytic, to name a few. For my purposes, I read the above point as expressing the need to acknowledge the worldview through which I will interpret history.

For my research, I will use a pragmatic perspective. Pragmatists subscribe to the notions of fallibilism (i.e., it is impossible to attain knowledge that is certain) and pluralism (i.e., it is impossible to attain knowledge that is universal).[704] Pragmatism will be important for doing my historical work because, "however strong the evidence in favor of historical statements may be, their truth can never become more than highly probable."[705] I will give my interpretations of history, knowing that there are always exceptions, and that my understanding of history could change, given more or different sources.

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[702] Bybee, "Historical Research."
[703] Rousmaniere, "Historical Research," 43.
[704] Thayer-Bacon, *Transforming Critical Thinking*. Take, for example, the question "What is Beauty?" It would be impossible to be certain that Beauty meant the same thing to every person, everywhere on earth, at all times during the history of knowledge.
[705] Ayer, *Language, Truth, and Logic*, 37.

John Dewey, an influential pragmatist, emphasized the contextuality in which intellectual thinking develops. He wrote, “Neglect of context is the greatest single disaster which philosophic thinking can incur,” and “No one ever had an idea except as he inhaled some of this atmosphere.”[706] All thinking is affected by the conditions of spatial background, temporal background, and personal biases. This is an important perspective for intellectual history because the ideas and discourse of the individuals under study will have to be placed in their proper contexts. To offer clarity, this means understanding the discourse within the spatial background of the northeastern United States and England, the temporal background of the last third of the nineteenth century, and the various personal biases of the individuals.

[706] Dewey, ”Context and Thought,” 88, 98.

APPENDIX C

HISTORIOGRAPHY

Overview

Historians throughout the nineteenth century essentially held one of two beliefs about science, industrialization, and their effects on society and education. For the first part of the nineteenth century the general opinion was that science and industrialization were harmful and unfavorable. They created burdens on society and social institutions, including schools, and any progress that was made during the Gilded Age was made in *spite* of science and industry. The number one enemy of these historians was big business.

These historians are broken up into two categories, namely Progressive historians and Neo-Progressive historians. The groups are both cynical, but the Neo-Progressives take their negative interpretation a step farther, portraying even more conflict and repression, and they do not hide their political loyalties.

The second general belief held by historians in the nineteenth century was virtually the mirror opposite of that described above. In the latter part of the nineteenth century these historians, characterized as Conservative historians, saw science and industrialization as beneficial and favorable. Science and industrialization were portrayed as spurring on positive educational reform, and unlike the Progressive point of view, progress made during the Gilded Age was made *because* of science and industry. These historians downplayed conflict, repression, and cynicism.

The Progressive Historians

Beginning at the turn of the twentieth century Progressive historians ushered in an age of organized, scientific historical scholarship.[707] Progressives as a group hoped for the betterment of society, and they created reforms to adjust to the changes brought on by the Civil War, Reconstruction, and the Industrial Revolution; their histories tended to stress the differences in groups, emphasizing class or sectional conflict. These histories were often deterministic, didactic, and moral in tone, with the intent to use history as a tool for building a new society.[708]

Progressive historians viewed the Gilded Age as a time of political corruption, societal excess, and economic inequalities and plutocracy.[709] The Progressive interpretation of the time period was often negative in character, with terms like manipulation, falsework, domination, extravagance, exaggeration, and decadence applied to the time period in general and businessmen in particular.[710] Historians like Ellwood Cubberley, Elmer Wilds, and Merle Curti embodied the Progressive spirit.

The main Progressive argument was that industrialization and big business were negative and adversely burdened extant social institutions. Cubberley's classic work on the history of American education, published in 1919, fits squarely within the confines of Progressive historiography. His history is Progressive in that it was scientific, didactic, and concerned with controversy. Industrialization and the resulting problems in education are seen in a Progressive

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[707] Kariel, "The Limits of Social Science." It seems that Henry Adams understood this change in American historiography, as he communicated to the American Historical Association in 1894 that historians must begin to treat man as the physical scientist had been treating nature.
[708] Farrell, "Schools of American Historiography."
[709] Harris, "Gilded Age Reconsidered."
[710] Belz, "American Response to Industrialism;" Harris, "Gilded Age Reconsidered;" and Breisach, *Historiography.* Belz uses the terms manipulation, falsework, and domination to describe the Progressive interpretation of bourgeois capitalism from 1865 to 1900; Harris uses the remaining terms to describe interpretations from the 1920s, which seems appropriate for usage by historians during the Jazz Age and the Roaring Twenties. Breisach makes the point that businessmen, above all others, were often the target of Progressive hostilities.

spirit; the cities had vast social problems as a result of industrialization, which made the extant school systems break down under the new strain; the ability to read, write, and cipher, which was once the mark of an educated man, hardly fitted man "to meet the struggle for existence in which he is placed, and certainly not fitted to participate in the complex industrial and political life of which he now forms a part."[711] The establishment of the common school is portrayed as a number of great battles on behalf of public education, where the forces of progress confronted the forces of reactionism.[712]

Elmer Wilds' 1936 history of education is similarly Progressive in spirit in that industrialization is seen through the lens of conflict. In his interpretation, the growing population of the Gilded Age fueled the economic problem of supply and demand, while the global interchange of materials led to economic rivalries between large nations and exploitation of weaker nations. A "sordid selfishness and disregard for social welfare" were the outcome of changes in industrial conditions.[713] In Charles Thwing's history of American education he writes that the Industrial Revolution increased public violence and lawlessness. The Gilded Age is seen as a time of materialism, where the chief domestic and social institutions were strained by changes brought about by industrialization.[714]

Merle Curti's *The Social Ideas of American Educators* is also classically Progressive in his interpretation of industrialization and its effects on education.[715] He attributes social and

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[711] Cubberley, *Public Education*. While Cubberley may not be wholly Progressive on all of the topics in this book (for example in his praise of education as a shining example of American democracy), this particular argument is Progressive.
[712] Cremin, *Ellwood Patterson Cubberley.*
[713] Wilds, *Foundations of Modern Education,* 550.
[714] Thwing, *History of Education.*
[715] Curti, *Social Ideas;* Petersen, "History of Science Education in America;" and Underhill, "Elementary-School Science." In opposition to the prevailing Progressive viewpoint, both Petersen and Underhill take the tack that industrialization, and especially science, were positive for educational reform. It may be that these two are Progressive in their interpretations of other things, but their un-Progressive tone on this particular subject may be more closely related to their own field and interest, namely that of the history of science education. It would seem

economic tensions to industrial and financial capitalists, the classic Progressive scapegoat of big business. Problems resulting from industrialization are seen as taxing educational leaders, who are portrayed as sinking under the weight of these burdens.

The link between industrialization and the resulting burdens on institutions is also apparent in Henry Adams' *The Education of Henry Adams.* He portrays science in terms of conflict; it threatens to dislocate social life and potentially shatter the intellectual and physical world.[716] To him science is mysterious, anarchic, and likely to destroy us.

What Progressive historians failed to consider are the greater complexities of the Gilded Age and the effects on education; selfish business and corrupt politicians were the focus of their discourse, with minor reflection on scientists and other, non-political and non-business, intellectuals who were influential during the age. Research on the intellectual discourse of science and education during the last third of the nineteenth century that incorporates scientists, educational reformers, university presidents, university professors, school administrators, doctors, and other intellectuals will allow a more complex interpretation of the intricacies of the age.

The Neo-Progressive Historians

Neo-Progressive historians are defined here as being Progressive in spirit, but even more conflict-oriented in their discourse than the Progressives. These historians wrote mostly during the times of social unrest in America in the 1960s. Their histories were more political in nature and depict history as more repressive than the Progressive historians. Breisach writes that historians during this time were reacting to more than simply America's changing society, as reflected in the Civil Rights Movement; they were also reacting to American's changing position

that science education scholars would naturally put a more positive spin on the topic of science education than Progressive historians from other fields and specialties.

[716] Adams, *Education.*

in the world, as reflected in the easing of the Cold War, Europe's declining dependence on America, and the Vietnam War.[717] The Neo-Progressive's main argument was similar to that of the Progressives (i.e., industrialization and big business were negative and adversely burdened extant social institutions), simply more conflict-oriented and more negative than the Progressives. Historians like Richard Hofstadter, John Sproat, and Lawrence Cremin embodied the Neo-Progressive spirit.

Richard Hofstadter's *Anti-intellectualism in American Life* is characteristic of Neo-Progressivism. Hofstadter exaggerates even more than the Progressives a negative attitude toward science and industrialization and their ramifications for education. The Gilded Age is portrayed as hard driving, competitive, ruthless, and materialistic; men had only "a barren idea of progress, a contempt for the past, and a blinding reverence for an unknown future."[718] Industrialization is seen through a lens of conflict, where businessmen and industrialists were the foes of mind and culture; the reader gets the impression that Hofstadter is almost *outraged* at science's utilitarian purposes.[719] In terms of industrialization's effect on education, Hofstadter's view is similarly Neo-Progressive; science did more than place burdens on the schools, it effectually destroyed American education by turning it into the merely practical, ruining the intellectual aim of education.

John Sproat's *The Best Men* has Marxist tendencies, and Sproat does not try to hide his political leanings, as was characteristic of the Neo-Progressives.[720] Liberal reformers are portrayed as lacking faith in the ability of the common American people to solve the problems of

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[717] Breisach, *Historiography.*
[718] Hofstadter, *Anti-intellectualism*, 241.
[719] This strikes me as a particularly preposterous point of view in the 1960s. Surely Hofstadter's life would be quite different, and his ability to make a living publishing books quite impossible, had science's utilitarian purposes *not* been realized.
[720] Sproat, *Best Men.*

industrialization. Labor problems are seen as a result of advances in industrialization, and the capitalist businessman is, similar to Hofstadter, depicted as a villain. As a Neo-Progressive, Sproat represents the Gilded Age as a time of intense conflict and violence, writing that the time was marked by "bloody rioting, prolonged and disorderly strikes, and ominous breakdowns of civil order."[721]

In the context of discourse on science, industrialization, and educational reform during the Gilded Age, Lawrence Cremin can also be considered a Neo-Progressive. In his historiography of American Education, written in 1965, the Industrial Revolution is held responsible for subjecting schools to severe strain and tension.[722] This seems like a Progressive view of industrialization and education, but can be categorized as Neo-Progressive because it heralds his more detailed interpretation of the topic in his *American Education*. In "The Metropolitan Experience" industrialization is still described in light of the burdens it placed on extant institutions; more than this though, it brought "painful problems," and it was responsible for social inequalities and dislocations. Also consistent with Neo-Progressive historians, Cremin understands education as being inseparable from politics.[723]

Problems with the Neo-Progressive interpretation of the Gilded Age are similar to those of the Progressive interpretation of the Gilded Age, namely that their focus on business and politics as the enemy is too narrow. The Neo-Progressive focus on conflict and repression, while certainly a valid representation of the time, is almost too simplistic. While big business and politics, coupled with science and industrialization, probably *were* negative influences on society at the time, this argument fails to delve into other factors affecting educational reform. Similarly,

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[721] Ibid., 225.
[722] Cremin, *Ellwood Patterson Cubberley.*
[723] Cremin, *Metropolitan Experience,* 470. As with note nine above about Cubberley, not all of Cremin's work is Neo-Progressive in spirit, but this particular point is.

the mindset that science and industrialization merely burdened the schools is overly negative. Research on the intellectual discourse of science and education, especially discourse that sees science in a positive light, will help to counter the negative viewpoint of the Neo-Progressives.

The Conservative Historians

Conservative historians looked at history through a very different lens than Progressive and Neo-Progressive historians. Conservative historians muted conflict, underplayed social strife, and celebrated the accomplishments and achievements of American democratic capitalism.[724] The Conservative historians were less critical of America and its institutions in their interpretation of the Gilded Age; instead, they focused on the longevity and durability of America's institutions and promoted the achievements of the age. Their main argument was that science and industrialization were positive for American society and American progress, and that educational reform, while still portrayed as an answer to societal changes, was a positive achievement. Historians like George DeBoer, Carl Kaestle, and Louis Menand embodied the Conservative spirit.

Conservative historians viewed science and industrialization very differently than Progressive and Neo-Progressive historians. To Conservatives, science and industrialization were good things. George DeBoer applauds science for helping to positively change our way of thinking about the world. Gilded Age science is seen as a productive power that helped us to understand and control the forces of nature.[725]

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[724] Farrell, "Schools of American Historiography;" and Amsler, "New Frontiers," 63. In his 1973 essay on science during the Gilded Age, Robert Amsler heartily celebrates the accomplishments and achievements of the Gilded Age. He praises advances in electricity, the steel industry, and oil extraction to an almost surprising degree. He writes, "Man's life has been improved and enriched through developments in the generation of electricity, the processing of steel, and the search for and use of petroleum." His praise for robbing the land of its resources is hard to comprehend in the twenty-first century, although forgivable in the 1970s.

[725] DeBoer, *History of Ideas*.

Craig Hazen paints a picture of scientific discoveries being useful and laborsaving, thus contributing to the improvement of life.[726] Neil Harris also praises the power of scientific explanation to improve life during the Gilded Age. He tries to revive the Gilded Age from its poor reputation by looking at the time in a much more complex way than previous historians by, for example, taking visual and plastic arts into consideration in his interpretation of the age.[727] This increasingly multi-faceted look at history is characteristic of Conservative historians.

In terms of industrialization's effects on education, Conservative historians are again more positive in their outlook than Progressive and Neo-Progressive historians. Carl Kaestle writes that commerce, communication, and capitalism actually encouraged literacy and mathematics, thus having a positive effect on education.[728] In his view, industrialism and advances in science spurred people to improve transportation, communication, business, and education. George DeBoer is similarly positive in his interpretation of the effects of industrialization on education. Advances in science spurred intellectuals, both scientists and educational reformers, to advocate the inclusion of science into the school curriculum.[729] While intellectuals may have been pushing for the inclusion of science into the schools before the Industrial Revolution, the incorporation of so much scientific advancement into people's everyday lives helped push the reform forward and finally succeed.

Louis Menand's *The Metaphysical Club* is another example of Conservative history. The Gilded Age is *not* portrayed as a time of intemperance, corruption, and consumption. It is painted

[726] Hazen, *Village Enlightenment.*
[727] Harris, "Gilded Age Reconsidered."
[728] Kaestle, *Pillars of the Republic.*
[729] DeBoer, *History of Ideas.*

as a time of transition, not decadence. Conflict is muted – almost altogether ignored – and the traditional American values of Christian piety and laissez-faire economics are emphasized.[730]

Conservative historians' conservatism manifests itself in the muting of conflict and the underplaying of social justice issues.[731] While their celebration of achievements and accomplishments is commendable, their conservatism fails to uncover important aspects of the intellectual discourse on science and education during the Gilded Age. Science and industrialism *did* create tensions in post-Civil War America, and these tensions should not be overlooked or diminished. An intellectual history of scientists and educational reformers of the time, especially one that includes counterpoints to their pro-science arguments, will reveal some of the important friction of the time period that was instrumental in creating the educational reform of adding science to the curriculum.

Conclusion

The focus of this research is the intellectual discourse of Gilded Age intellectuals, how advances in science and industrialization influenced intellectuals in their arguments for the inclusion of science in the school. The research focuses on various breeds of intellectual including scientists, educational reformers, university presidents, university professors, educational administrators, and others who advocated both for and against including science in the school curriculum.

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[730] Menand, *Metaphysical Club*; Winterer, *Culture of Classicism,* 118; and Kaplan, *Astors Owned New York.* It seems that we may be entering a Post-Conservative age of American historiography, at least as concerns interpretation of the Gilded Age. Historians such as Winterer and Kaplan are beginning to portray the Gilded Age in a sarcastic way. Winterer uses phrases like "chasing Mammon, worshipping at the altar of science, and surrendering to utility" to describe the time. Kaplan is even more sarcastic in his treatment of the time, often taking a half a page to list the outrageous food served at various Astor family functions.

[731] Foner and Mahoney, *America's Reconstruction.* Eric Foner and Olivia Mahoney's book on the Reconstruction is an obvious exception to this. Their focus on African Americans and Reconstruction is a commendable work on social justice.

The aim of the research is not to refute previous histories of the insturmental role of intellectuals like Huxley, Youmans, and Spencer in the inclusion of science in the school curriculum. The intent of this investigation is to look more in-depth at these men and then spread the net much wider to include intellectual discourse about science and education that has heretofore been overlooked. This includes intellectuals like classics scholars who advocated against science in the schools and doctors who wanted to educate against medical quackery. In addition to this, the research uncovers arguments made by less well-known intellectuals like Francis A. Walker and William Gardner Hale.

In repsonse to the Progressive and Neo-Progressive interpretations of the Gilded Age, this research looks beyond the selfish businessmen and corrupt politicans who dominated the focus of their histories. Similarly, the Neo-Progressive emhasis on conflict as the major interpretive framework is addressed in this research by looking at cooperation and consensus amongst intellectuals, while not overlooking conflict. Finally, the Progressive and Neo-Progressive mindset that science and industrialization merely burdened the schools is addressed by looking at intellectual discourse that sees these things in a less negative light, while not overlooking those intellectuals who were negative about the situation. In other words, this research addresses Progressive and Neo-Progressive histories by looking at the time period from an opposite viewpoint while also maintining the Progressive and Neo-Progressive viewpoint for balance.

In response to the Conservative interpretations of the Gilded Age, this research takes a similar approach as that stated above, namely looking at the period the opposite way as the Conservatives while still maintining their persepctive for balance. The Conservative historians muted conflict and tensions, and this is addressed by looking at arguments both for and against including science in the schools. The Conservative historians also celebrated the achievements and accomplishments of the time and this mindset is maintained in the research.

At the end of the nineteenth century science had made its way into most school curricula. There was both conflict and agreement, tension and cooperation; the Gilded Age was a time of decadence, but it was also a time of transition and progress. With that in mind, a blending of Progressive, Neo-Progressive, and Conservative interpretations seems a balanced and rounded out approach to understanding the issue.