A CRITICAL HISTORY OF U.S. SCIENCE EDUCATION

by

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Among other imperfections of the prevailing education, in all its grades, one of the most serious is a lack of the study of Nature... In place of the excess of verbal acquisition and mechanical recitation, we need more thinking about things; in place of the passive acceptance of mere book and tutorial authority... more cultivation of independent judgment--*E.L. Youmanns, The Culture Demanded by Modern Life, 1867.*

Certain defects of science courses in content and in methods are becoming increasingly apparent. In some respects, science teaching is not as closely related to the environment and experience of the pupil today as it was a quarter century ago. With the elaboration of apparatus and the increased attention to quantitative methods, there has come an aloofness from the experience of everyday life, so that the pupil may secure a high standing in physics, chemistry or biology without necessarily gaining an understanding of their applications. Moreover, teachers in science in some instances overemphasize the importance of formal and fixed procedures and, as a result, are not alert to utilize new opportunities-*National Education Association Report, 1918*

With each new generation our fund of scientific knowledge increases fivefold... In biology, the routines of teaching have drifted even farther from any approach that a scientist could recognize as an introduction to a science... We are profoundly convinced that the major fault in the teaching of biology... is that emphasis has been placed on authoritative content-facts, concepts, principles-instead of being placed on the investigative processes of science and the history of scientific ideas-*BSCS, An Inquiry into Life, 1963*

Despite the urgent need for science literacy, the... results [on federal science exams] prove alarming evidence that most of our students are not being prepared for the challenges ahead... The vast majority of students are learning very little science... They are taught to memorize some facts and vocabulary, but almost never to connect the knowledge into a coherent picture of how the world works and how we have come to know it-*George D. Nelson, Director of Science Education, AAAS, 2001*

It is hard to miss the unanimity of some of these critiques of US science education recorded over the past century and a half or so-student's have little "understanding" of science; they simply memorize facts and do "book work" at the expense of independent judgment, coherence and investigation; they are alienated from everyday life and unprepared. Why all this "failure" in America, one of the richest, most democratic countries in the world? Why can't we as a nation teach science right? Taking a step back, why do all these educators care so much about school science in the first place? Does this unanimity of criticism say something important about the very nature of science education? Perhaps still, it says something broader about the nature of US science and education? Perhaps it even says something about the very nature of the US itself?

1. US Science Education and the Structures of Liberal-Democracy

In order to sustain themselves, social systems generally need to appear sensible and correct to those that inhabit them. I will refer to the appearance of sensibility as a society's capacity for *rationalization*. A sense of a society's correctness is achieved through *legitimation*. This is especially true of modern, liberal-democratic societies like the United States which generally do not appear to rely on overt repression and violence, what Foucault (1978) refers to as "juridicial" power,[1] in order to survive. Rationalization and legitimation are achieved through a dependence on some fundamental structures, structures that are both conceptual and expressed in material life. Contemporary liberal-democratic societies like the United States rely on such fundamental structures-the "free" market (this is the "liberal" in liberal-democracy), representative democracy (this is the "democracy"), the family, law, work, entertainment/media, pathology, science, and education. Each of these, and their complex interrelationships, change over the course of US history and continue to do so. These structures, among many others, are utilized to provide the appearance of sense to relations, ideas, things, or practices which might not appear to make sense immediately (rationalization) as well as communicate that this system is deemed correct or the best (or on the way to being the best) by some sort of authority (legitimation). Often one such structure can use another, or several others, as sources of legitimation. While these structures are not "real," in the sense that they are

[1] Without dismissing the role of juridical power in the US (e.g. police, prison), particularly for the poor and nonwhite, I only wish to highlight that, in the tradition of Foucault, these legitimating forces tend to rely on "productive" power (e.g. normalization, identity consolidation) rather than "repressive" power, allowing the US to present itself as a "free" society.

abstractions from the myriad of activities which make up everyday life--they are, as Weber would say, "ideal types"--they are quite real in the sense that they organize the everyday experiences of most living in the West.[2]

In this dissertation, I will focus on the ways in which science, education and their co-operation in science education function as essential rationalizing and legitimating structures in contemporary US society. More specifically, my focus will be on the education in science given to students in US public schools. While this choice is a reflection of my own interest and politics, it is also a reflection of my sense that the ways in which these structures--particularly science and science education-can be used to legitimate the social, economic and political inequities of US society is vastly under-theorized, even in accounts which try to offer this history (Deboer, 1991; Hurd, 1961). Thus, I will focus a bit more on the "science" in science education rather than the "education." Much of this under-theorization has to do with the complex way that scientific knowledge promises to transcend knowledge acquired in everyday life, a point I

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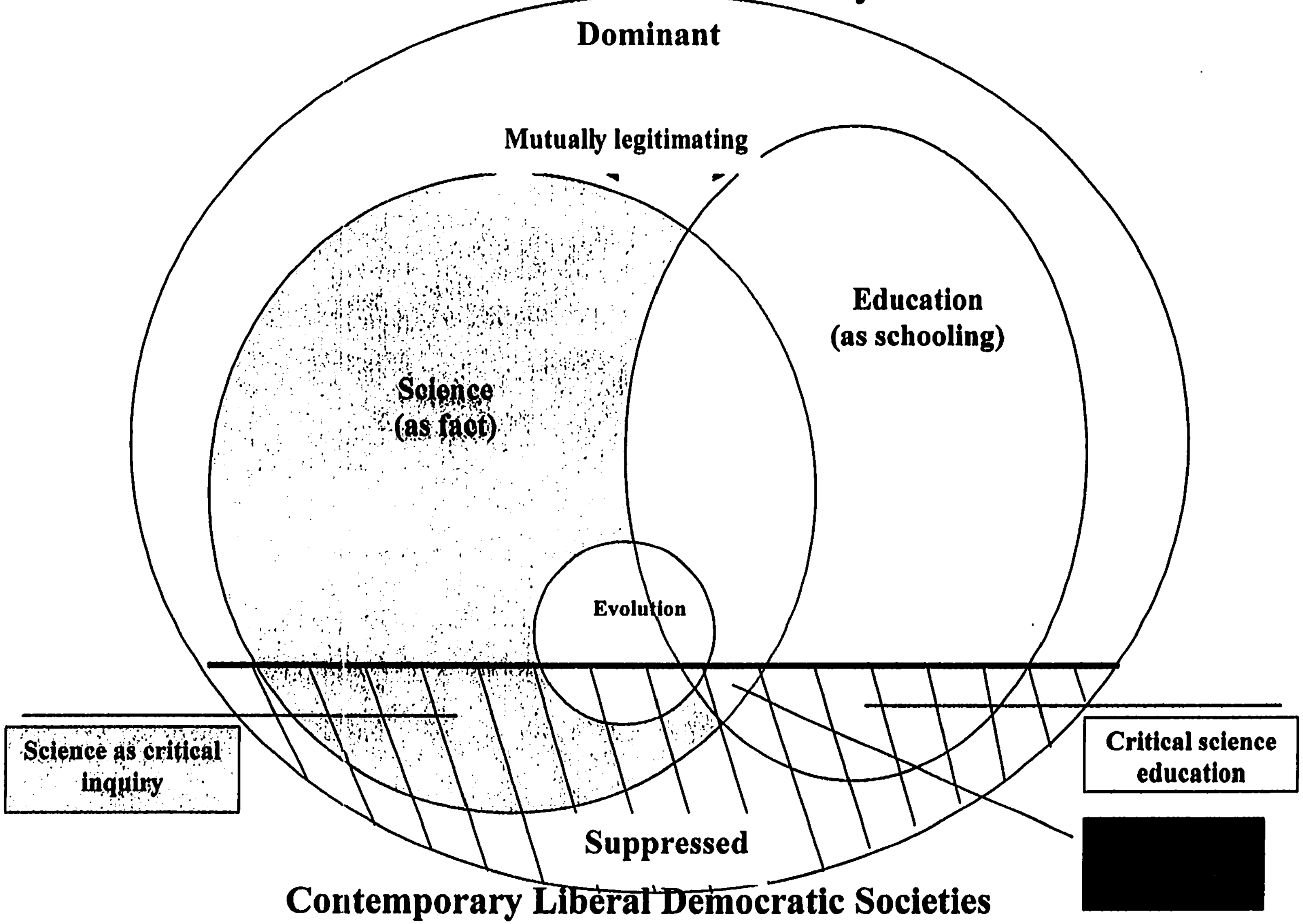
[2] They are not unlike what Bruno Latour (1993) has called actants—except of course, Latour would be suspicious of my seeming desire to give these "social constructions" life. While I agree with Latour in principal, the political and analytic force of these kinds of fictive structures is too great not to employ them in this type of critical project; these kinds of concepts do well to point out the ways in which seemingly disparate phenomena are part of a larger political project, while pretending not to be—a useful strategy for developing an alternative political consciousness and eventually, precipitating social change, the ultimate goal of any critical project. All the while, it is vital to remember that, with respect to this research, these totalizing abstractions tend to elide, ignore and even erase some of the moments of material life which do not "fit" into this seemingly seamless optic. In a similar vein, the re-telling of the history of these concepts misses the complex ways in which they play out and are resisted in practice. While I will try to identify some points of resistance, I will do so much more on the level of the concept rather than the level of practice. Perhaps later work should have as its expressed purpose further identification of these kinds of elisions, subversions and resistances. Still, I believe the force of these structures, particularly science/technology, with respect to the everyday life of most of us, merits putting some of the complexities of life on hold, if just for a few moments, so that others can be identified.

will pick up shortly. Moreover, I will examine the ways in which science uses education and education uses science as sources of mutual legitimation.

Before I do this, I want to make a few more important general comments about these kinds of structures. I already made one point, they change over time. Secondly, while they tend to be very complicated, they often express themselves in particular dominant versions which become so at the expense of others. In other words, there are versions of these structures that are more conducive to reproducing the specific social relations of contemporary US society better than others. Case in point, there are certain forms of education and science that are better at reproducing the status-quo than others. The same is true of science education. These tend to be the dominant forms. Yet, because the United States, in fact, liberal-democracies in general, depend on historically specific notions of "freedom" and in these cases "knowledge," the suppressed versions of these structures often reflect the presumed values of US society better than the dominant ones. Thus, these structures often utilize the rhetoric of mostly suppressed versions of themselves, versions which appear to give people the freedom to reflect on and change their lives and the world around them, to articulate dominant versions, all in the service of reproducing, more or less, the status-quo. This contradiction, the oppositional nature of what is and what is said to be, lies at the heart of most of the structures which ground US society. All of this might seem a bit abstract and a-historical so I will now turn briefly to my own theory of science/education so that I can flesh these ideas out a bit.

Science and Education as Key Rationalizing and Legitimating Structures of US Society



Because the interrelations of these structures change in time, and thus, my "theory" of science education is historical, I can only sketch some of my own assumptions as the entirety of these ideas will take this dissertation to develop. My theory of science and my theory of education reflect my own understanding of how they function in contemporary US society as well as represent a specific line of Western social criticism which follows from the work of Marx.[3] My notion as to the function of science in contemporary US society depends on several premises, the first of which is that science is one of the premier sites for legitimate knowledge production in the United States. The second is that, like much of the political and economic resources in US society, some people (as well as ideas and practices) have access to this site of knowledge production while most do not. In a sense, science will do for knowledge what representative democracy does for politics-offer access to a privileged few in order to protect knowledge/government from the masses.

Part of what distinguishes US society from societies of the past is the central place it offers science and technology. With respect to science, scientific knowledge permeates American life. In a certain sense, science is so pervasive that to try to identify its reach is not only futile, but leaves one with what looks like a caricature of science in the sense that it leaves out so much. In the United States, science is often said to answer a range of questions, to get at something resembling "truth" or "nature." It does so by using its methods to look at the world, identifying facts. Most people agree that these facts are

[3] This kind of history of ideas–in the context of a history of societies and practices—has a rich tradition in social theory beginning with Marx, Weber, Lukacs, Polanyi, Hessen, Horkheimer, Adorno, Bachelard, Foucault, Merchant, Toulmin, Young, Latour, Haraway, among others. Most of these figures appear in my bibliography.

inflected through preconceived theories, but working with theory-identifying or developing it--is generally the work of philosophers, or in the best circumstances, is regarded as the "fuzzy" part of science. In the end, science rises and falls by its command of the facts. Furthermore, because the results of science can act as truth, they can easily disguise some of the racist, classist, sexist and homophobic ideas circulating US society. In addition, the material expression of science-technology-is perhaps even more difficult to identify than facts. As others have argued, technology has become such a vital part of human experience that it is no longer easy to distinguish between the human and nonhuman (Haraway, 1997). One can easily find evidence for the premier place we offer technology in our lives by simply looking around. Because, in twenty-first century America, it no longer makes much sense to distinguish science from technology, when I use the term science, I mean something like what Bruno Latour (1979) means when he uses the term "technoscience."

My third premise about the function of science is that with respect to the legitimation of knowledge, science has usurped the place which was once accorded to myth and religion in so-called pre-modern societies. Science provides access to a realm of knowledge which not everyone has access to. Thus, by its very nature, science should be described as elitist or anti-democratic in that it devalues "everyday" knowledge--often labeling it "opinion"--the variant of knowledge that most people have access to, at the expense of scientific knowledge. If this were not the case, that is, if all knowledge was equally valued, science as we understand it would be superfluous. For instance, if everyone was able to create the kind of scientific situations wherein knowledge was produced, one would hardly expect there would be very much money to support all the research that might result.

Science, as we in the United States understand it, is a project of the Western European Enlightenment uniquely inflected through the prism of American-ness. The original (or at least, explicit on the level of rhetoric) animating intention of the Enlightenment project of science was to rid society of opinion and dogma-the kinds of ideas produced in everyday experience (Horkheimer and Adorno, 1944). Once upon a time, this had been true of the clergy. In the pre-modern world, there was an implication that access to the word of God was limited. If everyone had access to it, why listen to your Priest? Along came Luther and offered everybody access to God, precipitating the beginning of the end of clerical dominance and the beginnings of a scientific alternative. Now, scientists will tell us that this is unfair-science is precisely not religion or dogma because of its method. But, to take this at face value involves a leap of faith, just as the religious person takes a similar leap by allowing God to ground his or her knowledge. As this study progresses, I will argue that the function of science in the modern world is too similar to the function of religion and myth in so-called pre-modern societies for me to simply neglect these connections. Both systems are grounded in different, yet homologous, fundamental dogmas, one based in transcendence through God and the other transcendence through method.

Why would an institution that devalues everyday knowledge and offer only a privileged few accesses to the processes of knowledge production become so influential in the

United States? Why would a society seek to devalue the knowledge that most people have access to in this way? This question is a complicated one and, in a sense, will require this entire project to answer, but, needless to say, *it is useful in proving a story about the workings of the world which will reject the understanding of the world most people acquire in everyday life and experience*. Furthermore, if science is legitimating, than one can infer that it seeks to make particular aspects or understandings of the world acceptable *even if they do not initially appear to be so.* While this is the general logic of science, this does not mean that this logic goes unchallenged by individuals and groups, both from within and outside of science, some of which this dissertation will seek to capture.

One can also expect that these understandings legitimate the world which gave science life and which continues to give it life. As I have said, science rationalizes this world. It explains that, while certain aspects of the world which gave it life do not make sense on the level of the everyday, they do make sense on more fundamental or "scientific" levels. As I will review in more detail later, science is part of a world that arose in seventeenth and eighteenth century Europe, the modern bourgeois world, and this is, therefore, the world science originally sought to rationalize and legitimate. Today, the science I will study is a foundational structure of US liberal-democratic society and this is the world it seeks to legitimate.

As I have said, structures like science operate by articulating dominant expressions which successfully reproduce the inequities of a society, all the while, offering lip-service to alternate versions which are more in line with how that society views itself, or at least, wishes others to view it. Thus, there are two basic kinds of science. I will refer to the first as *instrumental* and the second as *critical.* I borrow the term "instrumental" from Max Weber to characterize the dominant form of science (Weber, 1968). This form is concerned mostly with facts and/or processes (technology) abstracted from their historical, political and theoretical contexts which are judged by their capacity to be useful. And yet, at the same time, in order to secure its quasi-religious legitimating status, such a science acts as if these facts/processes are closer to truth than others. This form of science is therefore practical and transcendent all at the same time.

On the other hand, the project of critical science--the term borrowed from Kant's *Critique of Reason*--is also concerned with looking at the world, a "looking" in the service of an ethics of action. Its "observations" are inflected through theory, history and politics. The development of theoretical or critical history lies at the heart of such a project and is the kind of science I will seek to practice in this dissertation. I will explain more of what this means in the next section.

As with science, US public education seeks to legitimate and rationalize the social relations of US society. Widespread compulsory education arose in the United States as a response to the social upheavals following industrialization, urbanization and mass immigration in the late nineteenth century and mass migration in the twentieth. It sought to maintain the social order through teaching workers the "skills" they needed to work and Americanizing the new immigrants (Bowles & Gintis, 1976). Public schooling spread in the US to provide new forms of technical knowledge required of workers in newly industrialized America (e.g. basic literacy, punctuality). There was always a class dimension to this. Working class people received working class skills, all the while, schools promised to be vehicles for social mobility, even though such cases were the exception. Today not that much has changed.

The most striking thing about contemporary US public education is the vast amount of inequity which it is rife with (Kozol, 1991). One can predict much about the kind of education a child will receive depending on their race and class. Public schools in poor and minority neighborhoods tend to have less funding, less experienced teachers, less resources, less staffing, larger class sizes, less flexibility when it comes to curricula, less experienced schools leaders and tend to come out worse on traditional markers of student achievement than their counterparts in wealthier neighborhoods (e.g. testing, attendance, graduation-rates) (Orfield, 2001). This list of inequity goes on and on. Regardless of whether these measures say anything about whether it is possible to get a good education in these schools, in terms of how US society currently measures success in its schools, those in poor and minority neighborhoods tend to come out at the bottom. Furthermore, as many educational writers have pointed out, what schools in more privileged areas tend to teach is less tangible--not so much knowledge, per say, as "middle class-ness." In these schools, expectations are higher. Courses tend to be less vocational. Students are expected to become familiar with the dominant ideas, works and languages of US culture. These students are taught how to act middle-class so that they become middle-class. In the less privileged schools, the lessons are different. Students are taught that they are and will be poor even if explicit rhetoric tells them otherwise and a few of them make it.

A Theory of Public Schooling in the US

- Response to cultural anxieties around the de-Protestantization of US culture.
- For the most part, reproduces the social relations and inequities of US society, particularly with respect to class and race.
- Is "blamed" for the failures of US liberal-democracy when it, in fact, embodies its most basic contradictions.
- Historical currents often shift its contradictory roles between integrating the unintegratible and social mobility.

In a nutshell, US public education is designed to reproduce and legitimate, more or less, the social relations we find in US society, a society laden with economic and political inequities. Furthermore, so much is laid at the foot of public schools-training people for work, Americanizing, social reproduction, skills transmission, social mobility, dealing with issues of equity, teaching "higher-order" thinking, sorting out those with "promise"-they are doomed to fail. In fact, I would argue, this inevitable "failure" offers the US an easy way to ignore its basic contradictions and inequities-if political and economic inequalities persist, blame public schools. This paradigm of education, what I will refer to as *schooling*, is the dominant form. However, as with science, it is not the only one. Just as instrumental science dominates and suppresses a critical science, so to schooling dominates and suppresses a *critical education.* Unlike schooling, which is concerned with integrating students into the apparatuses of production (e.g. work, family), critical education is concerned with turning students into thinking, reflective and skeptical citizens. This involves a broad or "liberal" conception of what kinds of education students need and views ethical, spiritual, psychological, aesthetic, and physical educations as key to the development of complete human beings. It is designed to reflect on and understand US society and its history just as much is it is designed to teach people how to function within it. While critical sciences and educations tend to be suppressed, they are not non-existent. One can find moments of both throughout the history of both science and education including in contemporary US society.

Science education sits at the nexus of science and education. In its dominant form (*instrumental schooling-based science*), it views education through the prism of schooling and science through the prism of instrumental science. It is thus mostly concerned with teaching students the dominant forms of science obsessed with facts and empty processes so that they can be integrated into US society as is. Such a science education often teaches students to become passive consumers of scientific knowledge as well as technology. In contrast, a *critical science education* seeks to create critical scientists in its classrooms. These scientists depend on observation, but also speculation, theorization, politicization and the study of history. They are scientists who regard science not only as a project of knowledge, but one designed for self, spiritual and cultural development. Because this dissertation is ultimately about understanding the role of US science education in the reproduction of these larger structures, one question which will come up again and again is why do we teach science in schools in the first place? Why do we say we teach science, but more importantly, how does the teaching of science function in relation to some of the broader structural dynamics I identified?

Finally, just as I must offer a theory of science and of education for this project, I must also, in a sense, offer a theory of the United States. The ways in which these structures reproduce their hegemonic forms while taking up the vocabularies of their subaltern forms-acting as if all science was truly skeptical and all education was truly interested in producing a reflective, thinking citizenry-is particular to a set of historical dynamics operating in the United States. Given that the US regarded its republican revolution of the eighteenth century as the successful one--in contrast to the French--nineteenth century America had a unique sense of itself as immune from the troubles of the Continent. Several features including a variant of Protestant Premillenialism, a vast frontier with abundant natural resources which kept wages high and a mostly agrarian economy created notions of American exceptionalism which regarded the post-revolutionary republic almost as God's kingdom on Earth (Ross, 1991). Towards the end of the nineteenth century, as disparities in wealth began to increase and heterogeneous immigrants, newly freed blacks, and a volatile working class began to call into question the logic of American exceptionalism, both science/technology and compulsory education were employed to communicate to the growing underclass what was special about the United States. Science, schooling and science education were responses to a crisis of the American gentry beginning around 1880 and lasting until about the First World War.

As I will review in more detail later, the growth of science and education were part of larger reforms seeking to protect a threatened status-quo. Given the way US society viewed itself, these new sciences and educations often characterized themselves as "critical," in the sense that I am using the term, solely interested in furthering democracy and freedom, all the while, helping to integrate the seemingly unintegratible into the dominant structures of American life. Notions of American exceptionalism drew many to certain ideas and practices which supported what they thought was unique to American society. The progressive nature of evolutionary thought and the progressive narrative of technological development were used to support this logic-the US was special because of its "progress" along evolutionary timescales as well as because of its pronounced technological development. With respect to science education, its technical logic is expressed best in a foundational tension between science-as-fact and science-as-process or inquiry, a faulty binary which only makes sense when one removes both fact and process from everyday life and history. For these reasons, among others which will become clear as this project progresses, I will focus on the articulation of these themes over the course of this history of US science education.

2. On Method: The Writing of Critical History

The previous theory of science and education provides a roadmap with which to read this dissertation. My goal is to tell the story of the development of these structures and their co-operations in the United States. Telling this story requires me to re-tell the story of the United States with this perspective in mind. The writing of critical history is not the same as the kind of history writing one usually finds in positivist histories. I am not interested in history "for its own sake" as much as I am interested in what Foucault has termed a "geneology" or a history-of-the-present. Its not that actual facts are so much irrelevant as that they are markedly biased, told from a perspective grounded in the present, importing a politics. Thus, the so-called facts I will choose to identify and the reading I will bring to bear on those facts are a function of a perspective. I will ask not only what happened in the past but how does that event or action function in terms of a particular social configuration. What, other than the explicit intentions of persons or agents, was the consequence of these actions or events? What kinds of politics did they import? How did it shape the world of today? To answer these questions one is forced to rely on theory rather than fact. This is not a weakness of such a project but its strength. By adopting a perspective and bringing it to bear on the data of the past, one is able to look beyond-the-given, to make explicit what time has ended up making natural. This is part of what it means to be critical. My own understanding, a product of my own history, politics and research, naturally, also represents the limits of this project. And yet, fallibility and relativism are not the same. I live and engage the world, giving me as much access to truth as anyone else-scientist or not. The job of a critical reader of this work is to always seek to make explicit what are the perspectives I bring to bear on these truths?

Reconstructing such a history begins with direct examination of some of the key documents related to science education; this includes calls to science education, documents related to science education policy and reform, textbooks, curricula and other reports. I will look at what they say, but more importantly, look at what else is communicated through them given the critical perspective I will adopt. Because I am interested in laying out the context of these processes, I will devote a lot of space to identifying the character of science and education at a particular moment in time and its relation to US society in general. This will require that I look at primary sources in philosophy, science, policy as well as important secondary sources which offer a perspective on this history.

The term "critical" is one that comes up frequently in educational discourses and it is vital that I make clear what I mean by the term. Unfortunately, the term has become so overused and vague that it no longer has much meaning. Everyone seems to agree, for instance, that schools should teach kids to think critically, but when one looks further one finds that what advocates of critical thinking generally mean is the capacity to think rationally, following premises to their logical conclusions or the use of this kind of thought to solve problems. This is not how I am using the term. To think critically implies two things. The first implies some sort of critique or at least skepticism. The second and more important meaning is borrowed from Kant. Kant uses the term in his *Critique of Pure Reason.* This critique, the first in a series of three, asks how it is possible for human beings to achieve knowledge with any certainty. Kant's famous solution was to argue that because human beings impose their own forms of thought on the world, within these limits, certainty is possible. In order to identify what these forms of thought were Kant asked what he termed the c*ritical* or transcendental question: what kinds of form must the mind impose on the world in order to know it?

Kant further articulated the dimensions of "critical" reason in his division between its three primary forms-*erklären, vershten* and *vernuft* or explanation, understanding and reason. The first type, explanation, is the mode of the natural sciences. It seeks to explain the world through causal relations, decontextualized variables and universal laws. The second form, understanding, is the mode of the human sciences. It seeks to understand the perspective of the human actors in the world. Its logic is one of empathy. Both of these are different than Reason in the third sense. They are, as I will explain later, identified by Max Horkheimer via his reading of Hegel as "subjective reason" in that they try to mimic the thinking of humans. For Hegel, they simply leave out too much. The alternative, what Max Horkeheimer calls "objective reason" seeks to understand an object in terms of its history and its relation to a totality. Furthermore, it does so from a perspective guided by an ethics or politics (Horkheimer, 1947).

The first point rejects the "snapshot" method that science tends to take. All objects exist in time and are thus better understood as processes rather than objects. They cannot be understood in depth except through a study of their historicity-this is why Marx's science was not simply materialism but a historical materialism. The second point recognizes that all object/processes are part of a larger system, they are, in fact, part of many larger systems and always play variegated functions in those systems. Again, in order to study said object, one needs to study those systems and relationships. Finally, in contrast to subjective reason which regards the accumulation of knowledge as an end onto itself, or at times, identifies narrow ends (e.g. technology, human comfort) which it acts to serve, objective reason is wholly devoted to a politics. It is unabashedly biased and does not look to obscure this in value-neutrality or method (Aronowitz and Ausch, 2000). My critical method, which is, at its heart anti-methodological in the sense that method has come to mean in the natural and social sciences, is intended to follow in this tradition of objective reason from Kant, Hegel and Marx to Horkheimer.

I will begin with my object, US science education, better described as a history of concepts/practice/processes from the mid-nineteenth century on, and ask the critical question. The critical question seeks to identify what the mind must already know or "take for granted" about an object in order to know it. A critical investigation, therefore, begins with the question of the taken-for-granted. It seeks to de-naturalize what people take to be natural so that the foundations of knowledge can be identified. Phenomenology refers to this as a "suspension of the given" (Schutz, 1970). By identifying the taken-for-granted, a critical investigation allows one to make explicit the assumptions that one and others make about the world so that one can evaluate them. These assumptions are grounded in socio-political interests which, through the naturalization these assumptions, can be hidden under a veneer of objectivity.

The dissertation itself will be divided into interludes and chapters. This is part of its method. The "interlude" sections will be more "theoretically" oriented, developing a conceptual or critical optic with which to understand the more "empirically" oriented chapters. The interludes and chapters will begin by offering a theory of science, a theory of education and/or a theory of the United States in each of the historical periods I will study. The chapter sections will look at several historical moments which help flesh these out further as well as identifying concrete instantiations, particularly in the case of science education. Although I use the word "theory," it is a bit misleading. The singular noun sounds more univocal than I wish it too and the dominance of neo-positivism in science makes one feel like theory's are, if not testable, empirically verifiable. This is not the sense in which I wish to use the term. Instead, for me, theory is a complex, heterogeneous, overarching framework with which one can look at the facts of history, uniting disparate ideas and practices in the service of an argument. Thus, I do not wish to dispute that history "happened," but only that the logic of history, understanding the effects of certain individual, social, ideational and material actors on the structures of US liberal-democracy, requires theory.

I will begin with a brief review of the origins of science in Western Europe and then turn to post-Civil War America, where debates over science and mass public education raged and the idea of incorporating science education into curricula became more popular. The three concepts I mentioned earlier, technology, facts/process and evolution, will figure prominently in this history. All will be used to cement the growing power and importance of a large-scale science and compulsory public education in the United States. Furthermore, these concepts will be crucial in developing a revised American exceptionalism at pains to distinguish between the United States and the Old World. In the twentieth century, similar dynamics will operate but instead of the Old World in general, American exceptionalism will seek to distinguish itself from socialism and later communism.

The first two chapters will focus on the period following the Civil War where one witnesses the dramatic spread of science, education and science education, including evolutionary ideas. The next two chapters focus on the early years of the twentieth century, the progressive period, wherein these versions of science and education were institutionalized and universalized (as well as challenged) as the United States was forced to deal with the changes precipitated by industrialization, immigration, urbanization and south-to-north migration. Both science and education were vital tools in these processes. Further, over the course of these years, as these structures became institutionalized, they began to look to each other for legitimation-science went further into schools and education sought to become scientific. The following two chapters turn to the post-war period, where science, education and science education were taken up in the battle against communism, leading to the creation of a huge scientific establishment, a sense of educational success grounded in international competition and a science curriculum serving patriotic ends. Finally, the last chapter looks at how the educationalization of science and the scientifization of education operate in contemporary schooling. It will regard the new standards-based reform movement and the debates over creationism and evolution as the culmination of dynamics which began over a century earlier.

PART ONE

THE ORIGINS OF US SCIENCE EDUCATION

First Interlude: The Birth of Enlightenment Science

This first interlude seeks to situate science in the broader context of the history of the modern West. Modern science, as a concept and as practice, emerged during the tumultuous years immediately before and during the European Enlightenment along with several other dominant political, economic, theological and epistemological ideas and practices in the West which I will take up-modernity, liberalism, Protestantism, democracy, and development/history/evolution. As a thorough understanding of my thesis depends on some basic familiarity with the history of these ideas as well as a recognition of my own take on these ideas, I have developed this "interlude" to introduce the reader to my own interpretation of Enlightenment and its relation to science, liberalism, democracy, modernity, development, and so on, which taken together, form the historical nexus out of which US science and US science education developed (see Figure Two). Subsequent interludes will introduce other key concepts including evolution, democracy, modernity, and globalization.

To say that these concepts emerged during the years of the growing power of the middle classes is not to say that they can simply be reduced to bourgeoisie "ideology" or some other variant of this thesis. First off, as I hope to show, most of these ideas precede this period. My concern here is with the context and impetus for the taking up and widespread dissemination of these ideas rather than their particular origin. Science especially has its own autonomy as it seeks to describe a world that is independent of humans. But, by definition, it could not be successful in this regard as this "independence" was as much a socio-political project as it was an epistemological one. After all, the autonomy of nature was part of what allowed science to reject the dogmas of the church. This makes the conceptions, practices and results of science an integral part of the social world and, by distinguishing the "social" aspects of science from the "natural" ones, one has already subscribed a historically specific bourgeoisie distinction which needs to be explained. What gets marked as "natural" and "social" is specific to a context. Finally, to say that science, or any other of these ideas for that matter, is "legitimating" or a form of rationalization in the interests of a particular group or type of society is not necessarily to dismiss it as irrelevant or evil. Ideas are interest-laden and interrogating these interests is part of any critical project. On the other hand, I do not wish to suggest that I do not have my own politics which is quite skeptical about the promises of the bourgeoisie project and what it has become in the United States. The writing of history is also always from a particular vantage point, engaged with a particular politics and this history is no exception.

A Theory of Science in the Bourgeois World

- Modern science arose out of a series of bourgeois revolutions—theological, political, economic and epistemological—which functioned to adapt people's understanding of the world to the needs of this new system.
- Modern "empirical" science was particularly suited to legitimate these systems due to its investment of epistemological authority in individuals (i.e. the primary it gives observation) and its capacity to enact changes which the developing market system needed, all the while maintaining what was valuable in the status-quo, particularly its naturalization of class and distrust of popular democracy.
- It did so through a set of inherently contradictory transcendent and immanent relationships—science transcended the world of the everyday in the sense that it took up the authority and legitimacy once accorded to religion; it retained its immanence to the everyday by focusing on the practical, particularly technology.

- Modern science's legitimating power is not identical to religion. Like religion, it must contain certain aspects of dogmatism to survive, but it holds itself superior to religion by maintaining its eminent practicality. Technology, as an expression of this practicality, becomes valued as an end onto itself and the term "modern" as well as the idea of progress help to clearly mark what is new about the techno-scientific world. In science education, this practical bent is transformed into a focus on the technical and methodological with a corresponding devaluation of the critical, theoretical, and historical.

- "Nature" as independent from humans is a product of modern science rather than a presupposition. This political act of construction rids nature of reason and value, rationalizing its domination. Two distinct yet related visions of science result from this—the first bent on "observing" nature and the latter, currently the dominant conception of science in practice if not rhetoric, is bent on controlling it.

I begin with a series of "revolutions" which occurred mostly over the course of the seventeenth and eighteenth centuries in Western Europe which had political, social, economic, theological, material as well as epistemological implications. These revolutions resulted in, what I will term, the modern bourgeois world, though this is not a very precise term.[1] Beginning in Europe with the somewhat simultaneous transition in the aforementioned realms of European life-the transition from monarchy to the nation-state/Republicanism, from autocracy to democracy, from feudalism to capitalism, from Catholicism to Protestantism/sectarianism, from a fundamentally agrarian society to an industrialized one and from myth/religious dogma to science-these revolutions eventually spread to most corners of the globe.

[1] I will use the term "bourgeois" to refer to the culture that emerged in Europe in the eighteenth century as a result of the growing influence of the middle-classes who sought to reduce the power of the aristocracy and church while developing their own variant of "aristocratic" or "high" culture. With respect to the US, the term in not easily applied. In the nineteenth century, there is no doubt that a white, middle-class, Protestant Gentry dominated US culture, but as the twentieth century progressed mass immigration and the development of mass culture makes the identification of a "middle class" culture problematic. Instead, in later sections, I will use terms like "US culture" or "US liberal-democracy" with the understanding that US society is by no means monolithic.

While the Enlightenment was a revolution of Reason, it depended on an earlier theological revolution. It was no accident that the earliest Enlightenment ideas could flourish in Protestant England, where the theological revolutions of the previous century, especially the influence of Calvinism, made the individual of primary importance. As the individual was now exclusively responsible for developing a relationship with God and responsible for his/her own salvation, a certain level of trust was, by definition, placed within the plane of human capacities. The authority of Rome was rejected.[2] While British Protestantism would be relatively tolerant of empiricism in the sciences, it would not be as open to theorizing and speculation as it would regard these as non-useful and thus non-Godly (Thompson, 1963). Hence, the later dominance of empirical science over philosophy in Anglo-American thought. In contradistinction, the sciences of the continent were enamored with the quasi-idealist mathematization of nature in Galileo and Descartes to a point in which they rarely sought empirical support for their ideas.

In Britian, these individualistic and tolerant ideals were supported by merchants and a growing capitalist class because a less prosecutorial state meant more freedom to trade and led to the development of a market economy, an economy which (a) set prices according to the vagrancies of supply and demand and, most importantly, (b) *delineated a political sphere which was distinguishable from yet always subordinate to an economic sphere* (Polanyi, 1944). Furthermore, the sensationalism of thinkers like Locke, Berkley and Hume as well as the utilitarianism of Hobbes would come together to form the basis of this new intellectual framework. Sensationalist psychology, by arguing that knowledge

[2] Ironically, in its turn to the literal text of the Bible, the Reformation produced much fundamentalism, all the while it was also the source of, first religion and later the intellects, new freedom from outside authority.

was a product of sensation, and therefore, a result of the experiences of an individual, reinforced the primacy of the individual by giving all people the capacity to know. Individual consciousness was invested with its own authority--individuals were the possessor of ideas, rights and capital (Macpherson, 1962).

The development of science was vital to the success of the market economy/liberal state on several levels. The social sciences, for instance, helped rationalize some of the new relations following the development of the market (e.g. Bentham, Malthus). On a concrete level, some of the insights of the natural sciences led to the development of technology which helped increase production and profit, though far less "science" was involved in this than is generally assumed. Technology did, however, make science attractive to nineteenth century bourgeois society which undoubtedly explains its rapid popularity during these years and its quick diffusion into the cultural imagination of that time. But more crucially, science had played a central role in shifting power from the Church to the bourgeoisie, especially with respect to the legitimation of knowledge.

Sixteenth century science arose in the context of the printing press, the Reformation, explorations to new parts of the globe and a growing middle class, all of which gave certain people an access to publication and peoples which they had not had before. This was especially the case in the two centers of Protestantism-the Dutch Republic and Britain. As Margaret Jacob (1988) documents, Galileo's confrontation with the Church must be understood in this context. Galileo sought support for his new science from the new classes of educated laity. Although Galileo was at pains to point out that this new science should not challenge the authority of Scripture, the implications of Galileo's work were clear to the Catholic Church-the "senses" would now become central to the production of knowledge as opposed to the word of the Pope. It is also in this context that early forms of science education arose. Another critic of the Church's Aristotelianism, Thomas Campanella, who published his *Defense of Galileo* in 1616, suggested that the study of nature should be encouraged among the people because it would direct people's energies toward productive enterprise and direct it away from political and religious dissent.[3] This might help to explain why the middle classes were drawn to science. On one hand, it was "progressive" in that it took power away from the Church and gave it to ordinary people. It also quickly became clear that some science could be used by private enterprise and more generally, to transform human life. This was made even more evident in Francis Bacon's *New Atlantis*. Furthermore, Bacon's idea of a laborious, mechanically oriented science mirrored some of the values espoused by Protestantism.

On the other hand, the mechanisms and mathematizations of Galileo offered a vision of the world that was stable, universal and timeless, a vision that likely did not do much to encourage radical social change. Here we have a "conservative" aspect of the new science--offering the middle classes a tool of epistemological legitimation which, although no longer controlled by the Church, would likely not result in radical change. The quest for certainty and stability by early scientists was very much related to the devastation following the Thirty Years War and the desperate need many people felt for a

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[3] A similar argument was made by W.B.O. Peabody a minister and early proponent of science education in the US during the Jacksonian era. By engaging and calming the mind, he claimed, science could divert people from dissent and politics (Daniels, 1968).

framework that would provide them with a certainty that could transcend human dogma and passion (Toulmin, 1990). This conservative impulse is also clear in seventeenth century Britain with the founding of the Royal Society. While some in Britain attempted to use the languages of science to offer plans for radical social reform, the members of the Royal Society sought to limit science to a focus on problems which did not disrupt existing social relations, problems like increasing food production and commerce (Jacob, 1988). Especially because science was to be a slow and careful process by which facts were collected, the knowledge resulting from science took a long time to become certain. Thus, science began to be associated with growing prosperity and the public good, but again, in ways that did not offer the opportunity for radical social change. By integrating a place for spirituality in the new sciences, a new generation of English scientists like Newton and Boyle ensured that the Protestantism of the British bourgeoisie would not conflict with the growing sciences, as would sometimes be the case with the French Materialists of the eighteenth century whose ideas would soon be taken up by the revolutionary masses.

The question of the democratic nature of science was made even more explicit in the contrasting visions of science articulated by Thomas Hobbes and Robert Boyle with respect to the establishment of certainty (Shapin and Schaffer, 1985). For Hobbes, the processes of scientific verification had to be open to the public so that its results could be accepted by all. Boyle, on the other hand, argued that verification take place in the space of the laboratory which need only be witnessed by the scientists of the Royal Society and the like. Only they could decide if the results of an experiment were to be accepted. It was Boyle's elitist vision of science that would be victorious. And, as I will argue later, the laboratory continues to signify a space cleansed of the masses. As science was integrated further into industrial production over the course of the nineteenth century, it became more explicitly concerned with its methods. Method offered the sciences a language for appearing to democratize knowledge while keeping the actual practice of science to a limited few. While theoretically anyone can learn the methods of science, and thus, create scientific knowledge, true science required an experimental method, a method whose practice required training. As is well known, in actuality, this kind of training was limited to a privileged few.

Returning to British science, by the end of this period, it became clear that appeal to the middle classes was explicitly part of the work of the Royal Society. From its inception, the society regarded the invention of mechanical devices as key to the labor saving techniques required for increased profit in industry and developed a programme of education (in the Robert Boyle lectures) by which Newtonianism was taught via illustrations from the application of its principles to industry (Jacob, 1988). For the Royal Society, there was no division as yet between "pure" and "applied" science, therefore all science was applicable to industry. The tension between the progressiveness and conservativeness of science provided new freedoms for capital and the development of technology in world that was relatively stable. One might expect that it also made the growing calls for a general science education attractive to the bourgeoisie, as scientists almost invariably used examples of what we would now refer to as "applied" science, particularly in industry, as a means to disseminate its basic ideas to the public.

Enlightenment thought was shaped by the results of science just as much as the results of science were shaped by the Enlightenment. The widespread dissemination of the heliocentric theory precipitated great changes in the relation of humans to the universe. While humans and their planet once stood in the center of everything, the Earth was now simply another planet orbiting the Sun. Instead of humbling science, though, this recognition pushed science to relocate the source of human exceptionalism in Reason. Thus, Enlightenment depended on the separation of the realm of humans from nature-as articulated by Descartes-so that nature could be purged of Reason and be properly humbled. This "new" Nature was a product of the Enlightenment and to become empirical science's principal object of investigation. Bacon's technocratic vision of science humbled Nature even further, turning it into a means for human ends and valuing that which humans created out of Nature more than Nature itself (Merchant, 1980). From this perspective, nature was autonomous (Burtt, 1924). Concurrently, it was determinate in the sense that its underlying operations could be revealed with certainty through science. As opposed to the Nature of the pre-scientific world which was fundamentally a part of social life, infused with meaning and final causes, perhaps even existing only for the sake of humans, this new Nature was not. Nature lost its inherent morality. It was, in Alexander Koyre's words, de-valorized (Koyre, 1957). The worlds of fact and value were divorced.

Suggesting that this development was somewhat autonomous is not at all the same as arguing that it was not related to the rise of the bourgeoisie. As many working in the tradition of Marx have argued, the transformation of quality into quantity, whether in the case of Newtonian science or commodities/labor now understood in terms of their market price/wage, are the kinds of homologous abstracting relationships which permeate bourgeois life. In a similar vein, Robert Merton's (1970) classic work details the way in which science was made attractive to seventeenth century England by taking up some of the values of that culture and time-religious explanations of divine wisdom couched in naturalistic language, technological utility and nationalist unity. But, the radical-ness of these ideas-the break with received wisdom and authority-was connected to their ultimate catholicism. So, to begin with, the original animating intention of the Enlightenment, while linked with the bourgeoisie desire to see a limited Church and a rationalized, orderly state to protect commerce, was none the less quite radical in its willingness to do away with received wisdom.

Unfortunately for science, its bourgeois character would ensure that this radical-ness would not be sustained and that science would become as dogmatic as the systems it wished to replace. For example, the science of nature of the Enlightenment was permeated with morality. Such was the case in one of the most "materialist" of French philosophers (i.e. those that sought to reject all non-matter based forms of explanation), Baron d'Holbach. A contemporary of Diderot and D'Alamberet, Holbach, in his *System of Nature,* rejected any philosophy of nature that tried to impose human values on it. Holbach even went as far as to purge his writing of any prosaic dimension. But, at the same time, his rejection of "value-imposition" was a means to allow philosophy to rid itself of superstition and develop an ethics based on Nature itself (Cassirer, 1932).

While today this might seem a bit naïve, it was quite radical in the sense that in its attempt to break with religion, the traditional source of ethics of that time, it looked to find a new source of value. However as philosophy/science was further integrated into the political and economic institutions of the Western European world, it lost this critical dimension and developed a conception of "value-neutrality" that had more to do with professionalization and legitimation than it did with the anti-dogmatism of the French Encyclopaedists. The burden of rationalizing liberalism and dealing with the dangerous spread of democracy was too much for the nascent sciences to bear while, at the same time, retaining its anti-dogmatic and skeptical nature. The more successful it became, the more science, as an institution, found itself protecting the system which gave it life. The scientific worldview had become central to bourgeois life.

Highlights of Argument-I

Period	Post-Antebellum 1865-1900	Progressive 1900-1917	Cold War 1945-1971	Globalization 1972-2003
Theory of US	Industrialization, growth of poor, create crisis for Protestant Gentry			
Instrumental Science	Science is professionalized; marked as technological and modern			
Schooling	Compulsory Schooling requires a modern curricula			
Science Education	Entry into US public education			
Dominant Discourses of Evolution	Contest between selectionism and acquired inheritance			
Critical Science/Education	nature study; classical, liberal, and broad curriculum			
Critical Science Education/Evolution	Nature Study as means to appreciate the nonhuman world; Lamarckian Socialism			
Educationalization of Science/ Scientization of Education	Science uses education to spread its influence			

Chapter One: Science Education as Modernity

Science education became widely accepted as a staple in US curricula as the country underwent industrialization over the course of the nineteenth century, particularly after the North's victory in the Civil War. The hopes of an agrarian democracy on the part of Thomas Jefferson, Benjamin Franklin and others slowly gave way to a new vision of the United States-an urbanized, advanced, industrialized and highly productive manufacturing and commercial society. While the old agrarian republic was dominated by the "gentlemen" of the eighteenth century, working alongside the new commercial classes, nineteenth century America had less need for the former figure as the country became dominated by an ever growing white, middle class culture which turned old Protestant frontier values like frugality and hard work into the business values of the Gilded Age. Science, and as I will detail in the next chapter, evolution, became essential to this process as they helped to offer a language for these changes which, at times, felt quite tumultuous and difficult to bear for many in US society. It was a language that clearly marked these changes as part of processes of development. In this case, science was not only reduced to technology, but technology became the highest expression of science. While some at the time might have argued that new labor saving devices would eventually decrease the wages of workers and, by increasing production, make the conditions of work less bearable, its technological and scientific sophistication said something about the very nature of US society.

In the post-antebellum period, the United States was on the way to becoming a scientific society. This is what was to make it unique. The qualities which science supposedly expressed--skepticism, rejection of authority, utility, modern-ness, morality, freedom--were, in fact, the very essence of the way the United States viewed itself. Even the principle of majority-rule was adapted to meet the needs of the framework of US science (though, only a majority of experts). Moreover, these were the antithetical qualities of the *ancien' regimes* of the continent which Americans had wholeheartedly rejected as they still remained rife with inequality, class strife and religious dogma. No matter that these authoritarian and old-world societies were actually out-producing the US in basic science and had developed a far more advanced research-university system to produce new scientific knowledge. But, where it really counted, in the practical expression of science, in the primary means by which science justified itself, technology, the United States was paramount. As the numbers of workers and immigrants increased and public education became available to the masses in the latter part of the nineteenth century, it was important that the new students were exposed to a curriculum which reflected what was special about the United States.

Science education did precisely this as in its rejection of dogma, authority, immorality, etc.; it mirrored the revolution against the Old World that Americans held dear. No matter that this revolution did not really produce the kind of democracy it claimed to. No matter that the exponential growth of economic inequality and exploitation produced by the unrestrained liberalism in the name of democracy of these years had very little precedent in the Old World. It was in technology that a key success of the American Revolution could be found and it was in science education that the inherent rationality and superiority of US society could be communicated. Much of these debates took place over the battle for a "modern" curriculum towards the end of the century. Like the revolution itself, the curriculum would seek to escape the classicism and authoritarianism of the continent. As I pointed to previously, both science and education use each other for legitimacy; in this case, science used education to further its entry in US thought, an instance of what I term the "educationalization of science." This is the story I will focus on in this chapter, a story of how and why science first came to US society and US schools. The particularities are unique to this period, but these basic themes will come up again and again over the history of US science education.

Figure Three: A Theory of US Science

- Modern science, in the US especially, would increasingly ally itself with democracy and shed much of the elitist appearance science had maintained in the Old World. This link would articulate a particular kind of US nationalism which regarded the "freedoms" of America in contrast to the authoritarianism of the aristocratic European world and later the communist system.
- The success of modern science in the United States operates on a model of popular scientific consumption in which the consumer of such knowledge/technology is clearly delineated from the producer. By offering science to everyone, science presents itself as democratic all the while it hides a more fundamental elitism. One of the primary jobs of US education is to prepare students for this role.
- The reality of US science can never match the kind of science that would receive popular support. Because most US institutions have to purport to be democratic and offer "equality of opportunity," science had to develop a new face. Thus, another role of science education is to create a mythic portrait of science that mirrors the values of US liberal-democratic discourse and obscure the ways in which science as it is actually practices does not and even cannot meet those values. This mythic vision of science is promulgated in schools, politics, the media, and scientists themselves and is precisely the kind of superstition science was supposed to protect us from.

2. Science and the Birth of American Modernity

The individualism of early US culture was well reflected in the early years of US science. The scientists of the revolutionary and post-revolutionary generation worked alone and were gentlemen, usually men of means and otherwise gainfully employed, who pursued science as a hobby. Their science developed from what Dirk Struik (1962) describes as Yankee ingenuity, seeking to find inventive solutions to the difficult conditions of early life for settlers in the colonies, particularly in farming. Many were raised in the traditions of participatory democracy unique to small town New England. Most were also generalists who worked in many areas of science, rather than the kinds of specialists usually associated with professionalization. Benjamin Franklin had tried to argue during the drafting of the Constitution that the federal government should subsidize some science in the form of some transportation construction costs, but instead the document only gave Congress power to "promote the progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries" (Dupree, 1957).

As the nineteenth century progressed scientists began to work collectively. The processes of professionalization had begun. Like its British counterpart, US science was a strictly inductivist enterprise. In what was regarded as the spirit of Bacon, most scientists went around gathering facts. To go further would embroil scientists in the useless theoretical meanderings of Old World philosophers (Daniels, 1968). While the professionalization of science began in Europe much earlier in the century, in the US, it began in the years following the Civil War. For instance, in 1820s Germany, when the first chemical laboratory was set up in Geissen, the first full-fledged research university, The University of Berlin, had been in operation for nearly two decades (Schnädelbach, 1984). Many early US scientists spent several years studying in Germany and other European centers of science and brought the vision of science they saw there back with them. Some of the more famous ones to make the trip included Benjamin Silliman, Joseph Henry, Alexander Bache and G. Stanley Hall. The early "professional" or full-time scientists were actually looked down upon by many Americans, regarded as lacking interest and ability in practical affairs (Bruce, 1987). As professionalization begot specialization, the sub-disciplines within the sciences were established. Professionalization also required legitimation and the acquisition of higher education became a necessary step in practicing science properly so that, essentially, scientific knowledge could be removed from the public sphere (Daniels, 1968). Only experts in science could now comment on it. Professional science required an elaborate system of specialized knowledge, technical methods and norms of behavior. As was the case with US medicine, professional science had to remove amateurs from its midst, creating tensions between science and the democratic spirit of US society (Starr, 1982). These tensions, between the elitist and democratic tendencies in US science, would play out over the course of its history.

While widespread federal support for US science was slow in coming, private industry quickly recognized the benefits that science could reap. The boom of 1865-1873 created a huge demand for engineers and many technical schools across the country were established to train them (Bruce, 1987). The most successful of the US sciences were those that could quickly prove their utility. Even de Tocqueville had noted that a democracy favored science that proved to be useful, though he suspected that, in America, the useful devices would lean toward those that impel short-cuts to wealth. Thus, when science began to sell itself to the American public, it was its utilitarian aspects that were highlighted. To this end, the idea that all technology was rooted in science, though far from the truth, was widely disseminated as the new technologies tended to impress the public the most. Science developed faster through its link with technology. While only 436 patents for inventions were granted by the federal government in 1837, by 1860 the number had risen to 4778 (Dupree, 1957).Through the popularity of Scottish-philosophy's "common-sense," the world of the scientist and the world of nature were conflated, rather than the former being an abstraction of the latter (Daniels, 1968). The fact that technology worked made the idea that science was simply common sense all the more attractive. Along with advancing the spirit of US nationalism, this was how scientists began to make the case to the public that their work had value and therefore deserved funding. In 1845, a popular, weekly technology magazine, *Scientific American*, was established. By the 1870s most major national newspapers (e.g. *New York Times, Harper's Monthly*) had regular science sections. At mid-century, public exhibitions and fairs across the country were created to showcase the latest in technological development and science/technology would become central to way late nineteenth century America defined itself.

More significantly, in terms of the growth of science, the industrialization of the United States in the second half of the nineteenth century precipitated some fundamental changes in the everyday lives of many Americans and the idea of modern-ness which implied a break with the past helped make sense of some of these changes.[1] In the first place, industrialization and the major changes accompanied by it-the rise of factories, further development and spread of the market, mechanization, urbanization, the expansion of wage-labor and the rapid growth of a poor underclass-radically transformed the mostly agrarian society of the pre-Civil War period. This period witnessed dramatic increases in the mobility of workers, disparities in income, as well as increases in the population of cities, resulting in new demographic, social and political arrangements. The idealization of technology would help make these changes more tolerable.

The rise of science accompanying industrialization produced a host of changes and products which further altered people's everyday lives. The first transatlantic cable was laid by Cyrus W. Field in 1866, making almost immediate communication with Europe possible and the planet feel a bit smaller. Experiences of time changed in this period as time was standardized, first by the railroad companies in 1883 and then by twenty-five countries at the Prime Meridian Conference in 1884. Simmel noted changes in the experience of time in his "Metropolis and Mental Life," particularly a new sense of precision and punctuality he attributed to the diffusion of pocket watches. Time was further "accelerated" by the invention of the telephone and telegraph in the late

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[1] The idea of a rupture was prominent in the work of many influential scientific and Enlightenment thinkers including Bacon, Fontenelle and the historical studies of Voltaire. As Matei Calinescu (1987) points out in his study of the "faces" of modernity, the concept of modernity was born during the Christian Middle Ages as way to distinguish between contemporary work and the work of antiquity. By 1170, modern poets were already considering themselves superior to the ancients and by the mid-seventeenth century, Pascal could write explicitly in his *Preface to the Treatise on Vacuum* that, in contrast to the ancients, "our view is more extended, and although they knew as well as we all that they could observe in nature, they did not, nevertheless, know it so well, and we see more than they" (cited in Calinescu, 1987, p.18). In literature, the famous *Querelle des Anciens et des Modernes* or Battle of the Books of the late seventeenth century reflected the extension of modernity's break with the past to matters of taste. At first, modernity positioned itself in an antagonistic relationship to its past. Eventually, however, it would come to ignore its past altogether.

nineteenth century. Canning and refrigeration altered the "temporality" of food. Later in this period, new forms of American music (e.g. Ragtime, Jazz) offered new sensations of tempo (Kern, 1983). Kern points to George M. Beard's newly (in 1883) identified "neurasthenia" or nervous exhaustion, a reflection of "intensified tempo" which some of these new inventions introduced into people's lives (cited in Kern, 1983, p. 125).

Passenger rail travel became an inexpensive way for people to travel. In the United Sates, the railway grew from a length of less than 10,000 miles in 1850, 30,626 by the start of the civil war, to almost 100,000 miles by 1880. In these years, more than 75% of earnings came from good traffic (Derry and Williams, 1960). By 1876 George Westinghouse's "air" brakes made rail travel appear to be safer and more comfortable. In the cities, electric trams moved people around, the first operating between Baltimore and Hampden in 1885. For some, particularly those in industry, the new and more popular mechanized modes of transportation (i.e. the railroad, steamship, trams) were much more than simply a convenience, but reflected a new transportation "release[d] from nature's fetters" (Schivelbusch, 1986, p. 11). While critics bemoaned the loss of the experience of travel represented in coach travel, supporters offered magnificent descriptions of the power of the new technology especially the ways it transformed time and space.

> We have seen the power of steam suddenly dry up the great Atlantic ocean to less than half its breadth... the Indian Ocean is not only infinitely smaller than it used to be, but the Indian mail, under the guidance of steam, has been granted almost miraculous passage through the waters of the red sea. The Mediterranean, which is now only a week from us, has shrunk before our eyes into a lake... the great lakes of the world are rapidly drying into ponds (ibid, p.10).

> The dangers to which the present coach system is obnoxious (such as the intractableness of horses, the imprudence of drivers, cruelty to animals, the ruggedness of roads, etc.), would not be encountered on the rail-way, whose solid

> basis and construction render it impossible for any vehicle to be upset or driven out of its course; and as the rail-way must be perfectly level and smooth, no danger could be apprehended from the increased speed, for mechanic power is uniform and regular, whilst horse-power, as we all very well know, is quite the reverse (ibid, p.11).

In the United States, as opposed to Europe where mechanization replaced a highly developed artisan and travel culture, mechanization allowed for the utilization of its vast natural resources and was thus regarded from the get go as creative. While in Europe the mechanization of transportation was oft regarded as part of the destruction of traditional culture, in the United States it was viewed as a means to gain access to an inaccessible wilderness. As Schivelbusch explains it, from the beginning, in the United States, industrial technology was regarded as a natural development, especially because its earliest, most visible expressions were in agriculture and transportation. Due to the shortage of labor in the US, in contrast to Europe, mechanization was even more essential to the development of industry. In the American collective unconscious, the industrial and American revolution remained tied to each other. As John Kasson (1976) points out, the post-revolutionary period witnessed many debates about the value of technology for the new nation. From a rejection of British goods after the passage of the Sugar and Stamp Acts to the writings of Thomas Jefferson and Alexander Hamilton, the question asked over and over was how would technology change the nature of American society? Yet, by the middle of the nineteenth century the debate had ended and technology became essential to the survival of liberalism and democracy. Inventors had become celebrities. Although Americans continued to revel in their new technology, particularly the railroad, visiting Europeans were often shocked by the dangerous conditions which American travelers accepted as routine. As Kasson (1976) tells it,

> Riding on an American train whose conductor was determined to make up time could be a harrowing experience, as Charles Richard Weld, an English tourist, discovered in 1855. As his train sped along, Weld's car began shaking violently and its ceiling lamps smashed to the floor. He remonstrated to the conductor, but to no avail. When finally the train jumped the tracks, all the cars except half of Weld's own and the engine were smashed. Yet to his amazement none of his fellow passengers wished to join him in protest; most, on the contrary, applauded the conductor's efforts to arrive on time (p. 48).

Machinery allowed Americans to fulfill their destiny, to cultivate nature. Needless to say, this established a unique place for technology and science in American society, a point I will pick up shortly.

In his study of the industrialization of light, Schivelbusch (1988) elegantly demonstrates how developments in lighting technology resulted in social and cultural transformations. Modern gas lighting began as industrial lighting around the turn of the nineteenth century. Like the railroad, its original use was mostly commercial until it eventually became a product for the masses. The earliest forms of electric lighting or "arc lighting" were used in the 1840s to light the Place de la Concorde in Paris. The difference between the power of the gas light, which had become commonplace, and the new lighting was enormous. As the *Gazette de France* reported at the time,

> Strollers out near the Chateau Beaujou yesterday evening at about 9 p.m. suddenly found themselves bathed in a flood of light that was as bright as the sun. One could in fact have believed that the sun had risen. This illusion was so strong that birds, woken out of their sleep, began singing in the artificial daylight... The light, which flooded a large area, was so strong that ladies opened up their umbrellas -not as a tribute to the inventors, but in order to protect themselves from the rays of this mysterious new sun (cited in Schivelbusch, 1988, p.55).

In addition to its ability to act as an objectification of the wonders of technology, electrification altered patterns in prevailing social arrangements. The new street lighting allowed the streets of the city to be enjoyed at night. In the United Sates, Midwestern and

Western cities set up tower lighting whereby entire towns were lit up by a centralized lighting tower. Electric lighting transformed the experiences of families in their salons as well as those of theatre goers with the development of the spotlight. Department stores used electric lights to light up their shop windows. Along with advances in the creation of glass windows, the lights pushed vendors to focus on window displays, expanding the temporalities of the market far into the night. Electrification, whose source was concentrated high-capacity generators, provided a centralized model for the new corporate monopoly capitalism. Technology became essential to these new economic arrangements. As David Noble (1977) points out, many of these new kinds of entrepreneurs began to identify advances in technology with advances in their corporations.

The new technological society created a need for a new explanatory language by which to explain these tremendous changes. Lewis Mumford explains that, as technology spread to many other domains of human experience in this period, humans increasingly came to understand themselves through the language of the machine (Mumford, 1934) It was not only the proponents of science who recognized this but the critics of technology ranging from the Methodists and Luddites to Thoreau. As science and religion became more antagonistic, especially after the rise of Darwinism, many turned to science. As Thomas Haskell (1977) explains it, as people became aware that the things around them were effects of distant and indirect causes rather than their own actions, they turned to the impersonal explanations of the natural and social sciences. Many in the American upper middle classes became more and more critical of religion and regarded science as the defender of free inquiry against the dogmatism of religion. Intellectual battles that had raged in Europe, wherein which science challenged the so-called superstitions of religion, became more visible in the United States during this period. While most did not reject Christianity altogether, they simply adjusted their understanding of Christianity to fit the latest results of science (Ross, 1991). As industrialization continued to disrupt and transform American social relations, the dominant classes of American life increasingly turned to science as a way of reasserting a semblance of order with respect to these changes. Traditional romantic notions of American exceptionalism were transformed. America's uniqueness was not its frontier nor its special relationship with God, but its valuation of science. Science explained this new society, but also, became its finest expression.

2. Science Education and the Battle over the Classical Curriculum

The nature of US democracy strongly shaped the development of its educational system. While in Europe, public education arose mostly as a means to transmit the new nationalisms of the nineteenth century through national languages and histories (Hobsbawm, 1962); the impetus to create public education in the United States was a function of the supposed lack of morality among the poor, urban dwellers, and non-Northern European immigrants. At first, the establishment of state funded education seemed to go against the very fabric of US democracy. This does not mean early Americans did not receive an education. Even de Tocqueville noted that it was difficult to find a person in New England not acquainted with basic knowledge of US history and government. The earliest schools were dominated by a clerical curriculum, designed to instill morality and were privately funded. By the eighteenth century, secular education began to develop. Benjamin Franklin, for instance, sought to open "academies," distinctly secular schools which supported vocational training and the teaching of other skills useful to life (Sizer, 1964). Franklin's curriculum included Greek, Roman and British history, geography and even some natural science so that merchants could know more about their trade, physicians about the body and the clergy about divinity. The aim of this knowledge was not for its own sake but to improve conduct. Federal support for education came after the passage of several bills in the 1880s and it finally received support as the middle classes became convinced that education, as Henry Steele Commanger put it, would be practical and pay dividends. This idea points to an interesting disjunction between the rhetoric of democracy and the reality of US schooling which would come up again and again in its history--the liberal arguments almost always beat out the democratic ones. Thus, only towards the end of the century, when it was widely regarded that the growing poor and immigrant population threatened the very fabric of American society, was there widespread recognition that universal schooling was in the interests of the United States.

By the mid-century science had already been established as a basic ingredient of British general education. The value of science, mostly in its technological expressions, had already been sold to the public by the Royal Society and its associates for much of the eighteenth century through public lectures around Britain. Many of these lecturers sought to "democratize" science by bringing it to the lower middle classes. But, by the early nineteenth century, widespread scientific education for workers and the poor, or as it was called, "mechanics," was conceived as a means to instill diligence in workers by showing them the wonders and inherent rationality of the new technologies of industrialization

(Jacobs, 1988). An early form of science education in schools was the Mayo's "object lessons" whereby they aimed at developing children's power of observation by focusing on and classifying objects. They regarded this form of instruction as preparatory to the teaching of science. The predecessor of these kinds of lessons which stressed direct contact with objects was Rousseau's *Emile*. In Britain, as in the US, early attempts to introduce science had argued it on the merits of its usefulness. For instance, science education was introduced in some of the early agricultural schools. It turned into a full fledged movement in the 1850s crystallizing around the idea of a science of common things and later, the natural history sciences. In the US, however, it was in the second half of the nineteenth century, particularly during the debates of the value of "classical" and "modern" education that teaching science in all schools became an issue.

In this debate, classics consisted of reading, writing, and math at the lower levels and classical languages, particularly Greek and Latin at the upper levels. The modern curricula consisted of science, history, English Literature and modern languages. Critics of the classical curriculum described the purpose of education as preparing people to deal better with the times in which they now lived, especially as their world was being increasingly dominated by scientific discovery and technological development.

Classicists argued that the purpose of a liberal education was the development of intellectual faculties and the development of an appreciation of the classics. The learning of science was narrowly utilitarian and debased, aimed at making money through vocational and professional preparation. Classics lead to refinement and generosity, science to crassness and materialism. In 1828, the "Yale Report," a reply to the critics of classical education, described classics as,

> useful, not only as it lays the foundations of a correct taste, and furnishes the student with those elementary ideas which are found in the literature of modern times, and which he no where so well acquires as in their original sources;-but also as the study itself forms the most effectual discipline of the mental faculties... Every faculty of the mind is employed; not only the memory, judgment, and reasoning powers, but the taste and fancy are occupied and improved... the proper question is,-what course of discipline affords the best mental culture, leads to the most thorough knowledge of our own literature, and lays the best foundation for professional study. The ancient languages have here the decided advantage (Yale Corporation, 1828, p.289-290).

To those that argued that education should prepare people for work, the authors replied, "the great object of a collegiate education, preparatory to the study of a profession, is to give that expansion and balance of the mental powers, those liberal and comprehensive views, and those fine proportions of character, which are not to be found in him whose ideas are always confined to one particular channel" (282). Thus, will one might sympathize with those that sought to modernize US education, at the same time, one finds a much broader sense of what constitutes education in the arguments of the classicists. Naturally, the classicists were not interested in democratizing knowledge--their curricula were for white, affluent, Protestant boys. Still, the idea that education was something far more than simply a tool for acquiring a vocation has much in common with my own critique of the schooling paradigm.

Defenders of science argued that science provided a superior form of mental discipline. E.L. Youmanns, a science textbook writer and lecturer as well as a Spencerian argued that mathematics, contra science, fell short on everyday or inductive reasoning. Drawing on J.S. Mill, he argued that science was better for "associating" ideas due to its organization. In 1872, he founded *Popular Science Monthly* in order to distribute basic scientific knowledge to the public. Youmanns described the problem in 1867 in his introduction to *The Culture Demanded by Modern Life,* a collection of essays by leading scientists which attempted to explain why it was necessary to understand science in order to adapt successfully to modern life.

> Among other imperfections of the prevailing education, in all its grades, one of the most serious is a lack of the study of Nature... In place of the excess of verbal acquisition and mechanical recitation, we need more thinking about things; in place of the passive acceptance of mere book and tutorial authority, more cultivation of independent judgment; in place of the arbitrary presentation of unrelated subjects, the branches of knowledge require to be dealt with in a more rational and connected order; and in place of much that is irrelevant, antiquated, and unpractical in our system of study, there is needed a larger infusion of the living and available truth which belongs to the present time (Youmanns, 1867, p. vi).

The modern world required a new kind of education as, in the past, "there was an abundance of metaphysics, but hardly a germ of that positive knowledge of the laws of mind, which could serve as a valid basis of education. The predominant culture of modern times had its origin more than eight hundred years ago, in a superstition of the middle ages" (3). Youmanns lays out an argument which we will see again, modern society is of a fundamentally different type and thus requires different forms of knowledge. This claim can be further broken down into three parts, (a) modern society is in its essence a technological/scientific society and, (b) modern society rejects the passive acceptance of authority, and (c) this rejection replaces this kind of acceptance with the direct study of nature. Note that, by itself, (c) does not necessarily follow from (b) or (b) from (a), and so on. Each of these propositions represents unique conceptions of science, the first a science that will transform nature while the last a science that will only reflect it. In his review of the first century of science in 1899, John Fiske makes a similar claim.

> When we look at the stupendous edifice of science... when we consider the almost limitless sweep of inorganic and organic chemistry... we must admit the fact, but our minds cannot take it; we are staggered by it. One thing stands out prominently, as we contrast this rapid and coherent progress with the barrenness of ancient alchemy... we see the importance of untrammeled inquiry, and of sound methods of investigation which admit of verification at every step (Fiske, 1899, p.4).

Not only does science bring us into a new age, leaving behind the world of the ancients, but this is accomplished through its unique methodology. Prince Albert of England offered a similar, popularized, version of this narrative in an address to his subjects at Birmingham and it is worth quoting at length.

> No human pursuits make any material progress until science is brought to bear on them. We have seen, accordingly, many of them slumber for centuries upon centuries; but, from the moment that science has touched them with her magic wand, they have sprung forward, and taken strides which amaze and almost awe the beholder. Look at the transformation which has gone around us since the laws of gravitation, electricity, magnetism, and the expansive power of heat has become known to us. 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; and she has other treasures in store for us, if we will but call her to our assistance. It is sometimes objected by the ignorant, that science is uncertain and changeable... while they think to cast blame upon science, they bestow, in fact, the highest praise upon her. For that is precisely the difference between science and prejudice; that the latter keeps stubbornly to its position, whether disproved or not, whilst the former is an unarrestable movement towards the fountain of truth, caring little for cherished authorities or sentiments, but continually progressing... having advanced another step towards the attainment of Divine truth (cited in Youmanns, 1867, p. 444-5).

It was not simply that science was associated with progress or even modernity, but that it reflected a fundamental transformation in the history and nature of human existence. Science has awakened humans, helping to break with the ignorances of the past. There is a sense in this address that the establishment of a scientific society, a modern world not trapped in the past, involves, if you will, a "leap of faith," a willingness to trust that science, through its methods, will provide us with some sort of salvation. It is hard to miss the religious quality of Prince Albert's call. While scientists themselves were generally a bit more restrained in their promises of what science might bring, one finds many instances of these same basic ideas in the rhetoric of scientists themselves.

Thomas Huxley, a crucial proponent of science education and Darwinism, argued that it is natural knowledge which shapes daily lives as millions depend on it and it defines his age, distinguishing it from early times. Science is valuable because of how it could be made use of by virtually anyone. Science provides direct contact with the natural world based on direct observations which develops the mind in unique ways. The study of science could not rely on textbooks. “If science education is to be dealt with as mere bookwork, it will be better not to attempt it, but to stick to the Latin Grammar which makes no pretense to be anything but bookwork” (Huxley, 1898, p. 125).

In science, one must handle objects and see how they work as “...it is his duty to doubt until he is compelled, by the absolute authority of Nature, to believe that which is written in books” (127). The laboratory will allow students to develop a clear conception of natural objects and move beyond a mere repetition of words. The teacher too would need to know science in a practical way otherwise it will lead to dead dogmatism. For Huxley, knowledge of physical science is required to “get on” in the world, particularly in securing an occupation. The more complex industry becomes, the more scientific knowledge is required. The measure of science education is that each child should be familiar with general knowledge of science and be able to apply the methods of science to any problem they might encounter. Such a curriculum begins with “physical geography” (the study of natural objects), and moves on to botany and physical science, the first dealing with forms and their relation to other forms and the latter with relations of cause and effect. Later, students can study the laws of social life which, "are as much the expression of natural laws as any others... no social arrangements can be permanent unless they harmonise with requirements of social statics and dynamics" (158). Huxley offered this caveat.

> If the great benefits of scientific training are sought, it is essential that such training be real: that is to say, that the mind of the scholar should be brought into direct relation with fact, that he should not merely be told a thing, but made to see by the use of his own intellect and ability that the thing is so and not otherwise. The great peculiarity of scientific training, that in virtue of which it cannot be replaced by any other discipline whatsoever, is this bringing of the mind directly into contact with fact, and practicing the intellect in the completest form of induction; that is to say, in drawing conclusions from particular facts made known by immediate observation of Nature (125-6).

Key to the scientific observation, therefore, is this direct connection with nature as this ensures that one is not swallowing old dogmas. One can imagine that this leaves the development of theory or the study of history far out of the project of science. Only this helps to prepare children for everyday life as "most of the business which demands our attention is matter of fact, which needs, in the first place, to be accurately observed or apprehended; in the second, to be interpreted by inductive and deductive reasonings, which are altogether similar in their nature to those employed in science" (127). As far as science education this involves directly handling and experimenting with objects.

> In teaching him botany, he must handle the plants and dissect the flowers for himself... don't be satisfied with telling him that a magnet attracts iron. Let him see that it does; let him feel the pull of the one upon the other for himself" (127).

Finally, the heart of science is the skepticism it requires. "Tell him that it is his duty to doubt until he is compelled, by the absolute authority of Nature, to believe that which is written in the books" (127). Good science education requires good teachers with knowledge of science.

> If he does, he will be able to speak of it in the easy language, and with the completeness of conviction, with which he talks of any ordinary every-day matter. If he does not, he will be afraid to wander beyond the limits of the technical phraseology which he has got up; and a dead dogmatism, which oppresses, or raises opposition, will take the place of the lively confidence, born of personal conviction, which cheers and encourages the eminently sympathetic mind of childhood (129).

Why the intense rejection of "dead dogmatisms" and "old authorities" for Huxley? I will take this question up in a moment, but it is hard to miss the connection between the increased popularity of this form of science and a culture seeking to rid itself of the chains-economic, political, theological--of the *ancien' regime.* Taking on the defenders of the classical curriculum, Huxley argues that physical science is of more value to students than a classical education and that, for the purposes of attaining culture, an exclusively scientific education can be as effectual. His statement is intended to oppose those in England who believed that culture is only attainable by a liberal education and the person trained through a science education is simply a specialist (e.g. Matthew Arnold). Culture need only "provide a complete theory of life, based upon a clear knowledge alike of its possibilities and of its limitations" (143) and this is precisely what a scientific education provides.

Herbert Spencer's all-embracing theory of evolution, found much success in the US (see Chapter Two). It was assisted by its reassuring and unifying theory of progress, its scientism and its clear language -as Oliver Wendell Homes put it, no "writer of English except Darwin has done so much to affect our whole way of thinking about the universe" (cited in Hofstadter, 1959, p.32). It requires an effort of the imagination, now, to appreciate the dominion that Spencer exercised over American thought from the Civil to the First World War. This includes his "social Darwinism," as well as his "utilitarianism" in education. According to Lawrence Cremin (1961), Spencer's writing on education was probably the most widely read writing on education in America. Spencer's ideas also influenced education in science. Spencer's writings on education consisted of four essays he contributed to the *Westminster Review, The North British Review,* and *The British Quarterly Review* between 1854 and 1859, the year of the publication of Darwin's *Origin of the Species.* The essays were published together in the US in 1860. There, Spencer insisted that the purpose of education was "to prepare us for living" and study should be judged by whether it has "practical value" and whether it would be useful later in life.

For Spencer, science was "vital knowledge" and not "dead formulas" because of its practicality. Laboratories help train one to draw conclusions from observations as well as in moral discipline.

> By science constant appeal is made to individual reason. Its truths are not accepted by authority alone; but all are at liberty to test them-nay, in many cases, the pupil is required to think out his own conclusions. Every step in a scientific investigation is submitted to his judgment. He is not asked to admit it without seeing it to be true (89).

Spencer argues that children should be encouraged to make their own investigations, being told as little as possible by the teacher. Classical education survived only as the badge marking a certain social position. Valuable knowledge was for self-preservation which could be acquired by studying science which was not then taught in most schools

In the first and most influential essay, "What knowledge is most worth," Spencer seeks to identify a way of cataloging knowledge as knowledge that accomplishes this is to be most valued. Spencer argues that the more directly a kind of knowledge is involved in self-preservation, the more important it is. Much of the knowledge that is generally taught in school should not be by these criteria (i.e. Latin, Political History) as they have "not the remotest bearing upon any of our actions" and "if of use only for avoidance of the unpleasant criticisms which current opinion passes upon its absence" (36-7). While Spencer acknowledges that the most basic knowledge for self-preservation "nature takes it into her own hands," schools are responsible for providing the rest. For instance, courses in physiology should be designed to teach children about health. Also important is knowledge required to gain access to a livelihood. Thus, as most people are employed in "the production, preparation and distribution of commodities" (44) the study of these objects should be of primary importance, a study that "depends on physical, chemical or vital properties… that is, it depends on science" (44).

In the essay, Spencer goes over all the major forms of science--mathematics, physics, chemistry and biology--and demonstrates how each is essential to making a living. Unfortunately, for Spencer this "vital knowledge" is ignored and teachers "have been mumbling little else but dead formulas" (54). While science is useful in the sharpening of faculties and the training of memory, its most valuable use is in training and heightening the powers of observation. He regards "object lessons" as a good example of this where… science directs one to "direct intuition, as textures, tastes, and colours are learnt" (107) and requires one to focus on the concrete (which will eventually lead one to the abstract or "rational") as well as make learning more pleasurable. After children are made familiar with the things around them children should be led on walks where successive facts (e.g. the parts of plants) may be introduced which will eventually lead children to want to preserve them and to the study of chemistry. Thus, science education must begin with the everyday and build on it.

In addition, science affords moral discipline as it rejects submission to dogmatic teaching as "its truths are not accepted upon authority alone; but all are at liberty to test them-nay, in many cases, the pupil is required to think out his own conclusions" (89). Spencer goes even further, "Every step in a scientific investigation is submitted to his judgment. He is not asked to admit it without seeing it to be true. And the trust in his own powers thus produced, is further increased by the constancy with which Nature justifies his conclusions when they are correctly drawn" (89). He quotes John Tyndall on inductive inquiry.

> It requires patient industry, and a humble and conscientious acceptance of what Nature reveals. The first condition of success is an honest receptivity and a willingness to abandon all preconceived notions, however cherished, if they be found to contradict the truth. Believe me, a self-renunciation which has something noble in it, and of which the world never hears, is often enacted in the private experience of the true votary of science" (cited in Spencer, 1963, p.90).

In fact, devotion to science has a religious aspect to it. It forces one to respect the marvels of Nature. This was, no doubt, a particularly Protestant conception of religion. On this he quotes Huxley.

> True science and true religion are twin-sisters, and the separation of either from the other is sure to prove the death of both. Science prospers exactly in proportion as it is religious; and religion flourishes in exact proportion to the scientific depth and firmness of its basis. The great deeds of philosophers have been less the fruit of their intellect that of the direction of the intellect by an eminently religious tone of

> mind. Truth has yielded herself rather to their patience, their love, their single-heartedness, and their self-denial, than to their logical acumen (90).

There are three important points we can garner about these early calls for a science education. First, they depend on some conception of the "modern" nature of contemporary society which is connected with science and technology. Second, that modern and scientific, by definition, reject authority and dogmatism. And, third, the science they describe is clearly moral and religious in character. It would be difficult to describe the science they describe as "secular" given how much it mirrors the Protestant values of that day.

As I suggested before, there are two competing views of science here. The first, inherited from Bacon and mediated through the scientific optimism of the Enlightenment seeks to master nature through technological development. It believes itself to be of a different nature than the dogmas and superstitions of the past. It is modern, all the more because it recognizes itself as such. Again, because of the artisan culture it replaced, these kinds of technologies had a much more difficult time in Europe gaining the kind of appeal they had in the US. In the case of the latter, with its shortage of labor and abundance of natural resources, these technological developments became essential to the success of manufacturing and commerce. Although by the end of the nineteenth century, the frontier was gone and immigrants had made labor far cheaper, the machine had become firmly implanted in the American imagination. The rapid invention and permeation of new technology communicated that there was something unique about US society. It had the ability to "develop" in ways that the Old World could not. Modern America, therefore, was exceptional in many ways, one of them being its unique relationship with technology. The Old World, hampered by authoritarianism and dogma could likely never achieve such success. This is why "bookwork" and "authority" came to represent the antithesis of science-they are part of the pedagogy of the continent. In the US, with the freedoms heralded by revolution, one is free to think independently. Or so science demonstrates. Naturally, this would come to entail not being able to think as a class, one of the major obstacles to a socialist movement in the United States. Ironically, this vision of science would quickly become anti-democratic in the US, a practice to be regulated by professionals.

Its competing version was far more democratic and is the beginnings of what I term, critical science. After all, anyone can simply record the data of nature. And such recordings generally reflected the genius of a "creator's" work and were hardly anti-religious in sentiment. While the former vision of science sought to harness nature to human ends, this vision sought only to observe nature, as a means to both enrich the knowledge of humans and seek God. This version was equally anti-authoritarian and anti-dogmatic. Here, the Protestant morality of scientists made much more sense-they were humbled and full of common-sense as well as were willing to take a "leap of faith." The problem was that, even within this vision of science, contradictory claims lay. On one hand, humans were humble, simply observing the world God had created. On the other, humans needed to have profound faith in their own capacity to reason as, through their own practices, they were required to rid science of dogma. In other words, it was not God who revealed dogma to humans, but humans who had to find and discard of it themselves. This requires a lot of faith in the powers of humans. If humans were intelligent enough to appeal to reason, perhaps they could control nature as well. Thus, this second conception of science was easily dominated by the first, technocratic vision. After all, in the end, science came to schools because industrial capitalism required a workforce with the kinds of technical knowledge people simply couldn't acquire from their families in antebellum, mostly agrarian, America.

Science Education in the United States arose as a function of these two competing conceptions of science and early advocates of this kind of education generally did not distinguish between one and the other. Thus science was both, technology and nature-study. Scientists were both arrogant in their claims to transform nature and humbled before the complexity of God's design, elitist in that they had the responsibility to regulate the boundaries of their disciplines and democrats in that they believed all could do science. The issue was that a technocratic science, on its own, could not fulfill an important function of science in liberal-democratic societies. It could not rationalize nor legitimate the present. It could explain some of what was good about the US and even why a science capable of being practiced by only a handful of people could be beneficial to all. Science's humanist arrogance and implicit elitism was not yet right for everyday nineteenth century Americans who could marvel at the wonders of technology but were not ready for a completely secular world-view. Nature study added a more spiritual, and more importantly, Protestant dimension. Still, one could not simply ignore science as in science lay the key to becoming modern. Lack of scientificity in US society would suggest a kind of backwardness that would not bode well with American's conceptions of themselves. On a more practical level, it needed the support of government and business and selling both of these aspects of science was simply smart salesmanship. Both conceptions were equally dogmatic, one constructing an a priori relation between modernity and technology, the other between common-sense, seeing (as opposed to thinking) and democracy, though as I suggested, in the latter, the germs of a critical science can be found. US scientists would always be smart enough to reference democratic rhetoric but, over the next century, they would create a science that, in practice, moved far beyond the scope of the people, although the science education they received would work hard to tell them otherwise.

Second Interlude: History Before Darwin

Evolutionary ideas were debated in the United States during the same years as the corresponding debate around the value of a scientific versus classical education. This interlude is intended to introduce the reader to new Western European conceptions of time, particularly the temporalities of nature, which shaped the reception of evolutionary ideas in the US. For much of its early history, American society had no need for a progressive sense of temporality. During the post-antebellum years, however, it would begin to adopt the sense of history which had begun to develop in Western Europe at the start of the nineteenth century. This nascent sense of historicity was as much a product of the romantic reaction against the Enlightenment as of the Enlightenment itself. Like science, Western time was also indebted to theology. The Greeks, for the most part, had no need for an overarching genetic framework, as, dominated by Plato and the neo-Platonists, Greek thought sought out essences immune to temporality and history. The ways in which objects changed in time was relegated to the realm of appearance and summarily dismissed.

With the rise of Christianity, a new sense of time emerged. Like their Jewish ancestors, the early Christians required a conception of progressive history because so much of their theology revolved around the second coming of a messiah. History, thus, became a stage for the playing out of this religious drama, the study of which gave believers a means to witness the intervention of God into the human world. This conception of history was eschatological in the sense that it held onto the idea of a future "end of history," the final goal and period of salvation forecast in the New Testament. In addition, history was futuristic in the sense that knowledge of the past could help to verify the possibility of this future (Löwith, 1949). Out of the Judeo-Christian faith in an ultimate purpose came the "secularized" notion of progressive history which came into being during the latter part of the Enlightenment as the influence of Cartesianism and its static, ahistorical system began to wane (Bury, 1932; Cassirer, 1951). Although bourgeois science would seek to rid itself of final causes and other explicit teleologies, it would embed salvation in its historical consciousness, one bound to the *eschaton* of progress. Progress would "secularize" bourgeois society as it masked the certainty of salvation.

Religion and eighteenth century science had come to a sort of understanding. As Newtonian science identified observable, fixed patterns which adhered in Nature, theologians used them as illustrations of the brilliance of the Divine. This kind of order implied an "orderer." The laws of nature were the means by which God organized the world: the more laws were identified, the clearer the actions of God became. This way, science came to serve Christianity. Natural theology provided evidence of divine work in the regularity of the world. After the Protestant Reformation and Luther's return to the scriptures, the time-scales of the Bible were established even more firmly than before (Toulmin and Goodfield, 1965). The biblical account of creation became a central part of the Christian faith. Scientific theories which challenged the scriptural account were generally regarded as heretical unless they could quickly be subsumed within the creation narrative. This was the case with the Nebular Hypothesis proposed by Kant in 1755 and Laplace in 1796 which challenged the scriptural understanding as to the age of the Earth.

Long before Darwin, however, geology was the first science to fundamentally challenge many aspects of the scriptural account of creation.

For most of the eighteenth century, the findings of geology seemed to provide evidence for a deluge of the kind identified in the biblical account of creation. For instance, the discovery of marine fossils on land implied that the world had once been covered by water and the Earth's strata were considered to have been caused by this flood. One influential example was Thomas Burnett's *The Sacred Theory of the Earth (*published in 1684 as *Sacra Telluris Theoria*) which offered a mechanistic vision of the creation narrative. James Hutton's publication of *Theory of the Earth* in 1785 questioned this. Hutton explained the construction of the Earth's surface using two processes which shaped the Earth over a great period of time: erosion (neptunism) and heat (vulcanism). While Hutton affirmed that these processes were set in motion by a creator, his work appeared to question whether there was in fact a great flood, and perhaps most importantly, made it almost impossible to accept the scriptural account as to the age of the Earth. While he recognized that both erosion and heat were key geological processes, he was regarded in his time as an opponent of an erosion-based explanation of the formation of the Earth's surface. By the late eighteenth century the opposition between neptunism and vulcanism had become a sign for a larger debate about the importance of God's role in the day to day workings of the universe. Any position which appeared to deflate the importance of God-as vulcanism was regarded as doing-was put into a class of "atheistic" theories emanating from the French, ideas responsible for their revolution and its bloody aftermath. Opposition to any sort of naturalism was intensified by the growing fear of the English middle classes that they were next. The link between naturalistic theories of evolutionary change-both geological and later biological-and atheism/revolutionary upheaval became entrenched in the European and particularly Anglo-American imagination, to the extent that opponents of evolution-some of whom still genuinely believe that evolutionary ideas were responsible for secularism and social instability--could still take up these discourses in the present day.

The theological implications of Hutton's uniformitarianism-the idea that one could explain the origin of the Earth in uniform ways, through a gradual process-was dulled by Georges Cuvier's comparative anatomy of fossils. He studied the relation of differing fossils to their place in the Earth's strata and found radical discontinuities between plants and animals of different periods. This allowed him to assert that there had been a great deluge after all. Cuvier's catastrophism argued that the Earth had experienced several great catastrophes resulting in mass extinction of species and the creation of new species. For him, species were fixed and immutable classes created by God. Catastrophist geology seemed to reconcile, once again, the findings of science with the accounts of theology. This reconciliation was once again undercut. In biology, Cuvier's intellectual rival, Jean-Baptiste Lamarck, began to reassert the case for organic transformation. In Britain, Charles Lyell's *Principles of Geology,* published in 1830, once again reasserted the uniformitarian case. For Lyell, geological evidence led one to believe that the Earth's surface was a product of processes operating over an extensive period of time rather than a deluge. Still, he did not directly reject the catastrophist position as much as argue that it was superfluous and unnecessary. As many know, Darwin read Lyell on his voyage on the *Beagle*. After Lyell, geology could not longer be used as evidence of the Divine, but biology, that is the origin of the species, could.

Before the publication of *Origin*, however, Robert Chamber's *Vestiges of the Natural History of Creation*, published anonymously in 1844, was one of the first well-read (if not, well-received, at least by the scientific community) work to make the case for evolution in the English world. While others had mentioned the idea of organic evolution, *Vestiges* moved the question to a whole new level.[1] Although many would reject Chamber's use of "disreputable" scientific ideas like phrenology and spontaneous generation, his basic evolutionary argument was not unlike Darwin's in certain respects. He began with the evidence of geology: the fossils which had been uncovered appeared to become more advanced the more contemporaneously they existed; in fact, one could trace, step by step, the history of life through the fossil record from marine life to land animals. Each of these species seemed to appear when the environmental conditions were ripe for them and could be linked through transitional stages to their ancestors. Also, Chambers evoked the principle that individual development appeared to mirror species development (ontogeny recapitulates phylogeny) and that the structural relations organized by biology were virtually homologous with the history implied by the fossil record. These processes lead to the creation of humans. All this, according to Chambers, was in line with the scriptural account, as traditionally understood. The idea that God

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[1] The question of whether the universe was static or changing had been around since before Plato--with Parmenedies and Heraclitus taking up the two opposing sides of the debate--and notions of evolution popped up here and there, including in the work of Lucretius, de Mailett (*Telliamed*), de Maupertuis (*Système de nature*), Diderot (*Pensèes sur l'interprètation de la nature*), Buffon (*Historie naturelle*), Rousseau (*Discourse on the Origins of Inequality)*, Erasmus Darwin (*Zoonomia*), Lamarck's controversial but not widely read writing (*Philosophie Zoologiqu; Animaux sans vertèbres*) and Geoffrey Saint-Hilaire—particularly in his debate with Cuvier (1830-1832).

created each species separately, Chambers remarked, would "surely be to take a very mean view of the Creative Power; in short, anthropomorphize it, or reduce it to some such characteristic as that borne by the ordinary proceedings of mankind" (cited in Millhauser, 1959, p.92). Instead, it made more sense to imagine God creating the process itself and then stepping back and watching it unfold.

For the first few years after its publication, *Vestiges* was one of the most widely discussed books in London (Millhauser, 1959). Twenty two editions appeared from 1844 to1860. While the book enjoyed popular success, it was widely criticized by the scientific and religious communities. In a review, Adam Sedgwick, the British Geologist and one of Darwin's teachers, described it as "self-condemned by contradiction and absurdity" and was repulsed at its notion of "monkeys breeding men and women" (cited in Millhauser, 1959, p.122). For those sympathetic to evolutionary ideas, Chambers conflated the general idea of natural law with a more precise mechanism which could lead to evolutionary change, one which he did not specify (Young, 1985). Another critic of *Vestiges* was Darwin himself, who described it as possessing "little accurate knowledge" and "a great want of scientific caution" (cited in Millhauser, 1959, p.150). He did recognize, however, that *Vestiges* had "done excellent service in this country in calling attention to the subject, in removing prejudice and in thus preparing the ground for the reception of analogous views." Later, in his effort to create a viable "Darwinism," Huxley would work hard to create distance in the public's mind between Darwin's work and previous theories of transmutation particularly that of Chambers, as any association with the idea of spontaneous generation made Darwin's work far more controversial than it had to be.

The religious criticism seized on the scientific criticism but added that *Vestiges* flaw was far more basic: it turned God into an empty and passive being (Millhauser, 1959). What then is the point of prayer and morality, they asked? These were some of the same questions that would be asked of Darwin. The question is a fundamental one--what role does the kind of naturalism implied by evolution leave for God? This question, which would come up again and again over the history of evolutionary thought, is an ethical and political one which asks, what kind of world are we left with when we understand God in this way? On one had, some would later argue, it was a world where the scientific and the moral were conflated and inequity was rationalized. Another answer, though not always stated explicitly, was to point to what happened to the French. Without God they were forced to endure several violent revolutionary upheavals and the rise of militant anti-bourgeois and anti-clerical groups who sought the change the natural order of the world imposed by God.

Robert Chambers was not the only one to "prepare to ground" for Darwin's work. As Adrian Desmond (1989) has shown, to see *The Origin of the Species* as the turning point in the history of evolutionary theory, as many scientists and historians do, is to miss much of the radical evolutionary ideas permeating the British medical schools in the 1830s and 40s. While it is correct that for the scientific gentlemen community, the governing class of British society, it was Darwin's book that finally made evolution respectable and acceptable, several decades before the doctrines of Lamarck and his student Geoffrey Saint-Hilaire were taken up in the mostly working-class medical schools of England as they tried to reject the class rigid categories of idealist biology. They rebuffed the Paley-inspired idea that the perfect design of the world suggested it was best of possible worlds, an idea that was then used to rationalize existing social relations.[2] In other words, evolution offered working class militants, atheists, socialists, radical phrenologists and other critics of the British class system, a radical doctrine of change with explicitly political implications aiming toward ridding Britain of the priest class of gentlemen which dominated government and science. These radicals sought to replace these public gentlemen with a paid class of administrators and professional specialists.[3]

Their brand of evolution was far more anti-Malthusian than the version that came to fruition after 1859. Particularly relevant was Lamarck's radical idea that species could transform themselves through changes in their behavior-all this without the aid of the divine. As Desmond points out, Chambers himself, influenced by his fellow Scots who had spent time at the Paris Faculty of Medicine in the 1830s studying the philosophical anatomy derived from the *idéologues*, or French materialists, gave a providential veneer to this anti-theistic science which made it more respectable. Some of this can help explain why Darwin's work was so influential so quickly--evolutionary ideas were already very

[2] William Paley's *Natural Theology* (1972), which dominated British biology for much of the nineteenth century, explained that the persistence of complex adaptations by different species to their environments was a sign of God's perfect design.

[3] As was the case with science itself, once this class of specialists and experts was established, the radicalness of this move would be cut short as they would quickly become integrated into the bourgeois order.

much "in the air" and Darwin's Malthusianist inspired principle of natural selection offered a version of evolution that was more satisfying to the bourgeois elite as it could be easily used explain away social and political inequalities and argue against tampering with a natural process. Today it is common to reject "Social Darwinism"--the idea that "survival of the fittest" and "competition" are ideas that are equally applicable to society as to nature--as a deformation of Darwin's position, but this is not quite the case. As Adrian Desmond (1991) has shown in his biography of Darwin, Darwin fully understood that his ideas would be used to combat some of the more radical critics of British society. On some level, this would involve naturalizing inequality and Darwin's Whiggism as well as his general distaste for those he regarded as trouble makers was sympathetic to such a move. Therefore, in Britain, as would also be the case in the United States, a more radical variant of the historicity of nature would be dominated by a more conservative one.

Darwin's role in the development of evolutionary thought is complicated. He is generally credited with identifying the mechanism of evolutionary change-natural selection. Again, this idea had surfaced before, well before even Malthus. There are even preliminary notions of a "competition for survival" in the writing of Lucretius. Darwin's theory of evolution would depend on three ideas. First, that more complex biological form follow simpler forms in time. By the mid-nineteenth century this first thesis was widely circulated. Second, he accepted that these complex forms *descended* from simpler forms. Again, while there was debate about this question, it was a position that some had taken before Darwin including his grandfather, Erasmus Darwin, Lamarck and Chambers.

Finally, the third position--the decent of higher species was a consequence of variation and natural selection. Darwin was not the only one to recognize the importance of variation, this is part of what motivated the great taxonomies of the eighteenth century, but the idea that a principle mechanism by which evolution occurs was natural selection is generally regarded as the idea which set forth the Darwinian revolution in biology in that it appeared to explain the evolution of life without any recourse to supra-natural explanations or mechanisms.

It is well known that Darwin was not fully convinced that natural selection was a satisfactory way to explain evolutionary novelty. With respect to getting rid of the unfit, Darwin, as well as others before him, recognized that competition for survival played an important part. Towards the end of his life, Darwin became much more sympathetic to the Lamarckian position. This makes the unique contribution of Darwin a bit more ambiguous than the idea of a "Darwinian Revolution" implies. Much of what Darwin accomplished was to de-radicalize evolution and reorient its political implications, making it less of a resource for those advocating radical social transformation. Furthermore, the novelty of Darwinism was much more related to its rejection yet usurpation of theology. While Darwin rejected non-mechanistic explanations, he also borrowed an idea from the catastrophists, the idea of progressive succession. Up to that time, this idea had been thoroughly infused with religious notions (Toulmin and Goodfield; Brooke, 1991). Progress in nature was a sign of the Divine. By ridding progressive succession of its theological underpinnings (or at least, playing them down), turning change into a "random" process rather than an expression of God's plan, Darwin created a secular biology which combined the commitment to mechanism of empirical science with a bourgeois-inspired version of progress. An effect of this new synthesis was the implication that the changes in the European World precipitated by the development of a world market and so on, while at times felt miserable to some, were all part of a broader movement of progress. Perhaps even a part of God's plan. Even though Darwin and his followers would be at pains to point out the random nature of evolutionary change, it was its progressive undertones that made it so attractive to late nineteenth century thinkers, including Darwin.[4] It rationalized the bourgeois universe in a secularized theology which felt familiar to Christian Europe.

Nineteenth century evolutionism must also be understood as part of a larger historicist intellectual movement which included figures as diverse as Hegel, Marx, Dilthey and Comte. These forms of historicism depended on particular notions of the interconnectedness of progress, necessity and law; that is, the laws of nature necessarily led to progress (Mandelbaum, 1971). Thus, these laws are far more the abstractions created by scientists, but adhere in nature itself and appear to guide the evolutionary process. In fact, they can and were read by some as evidence of Divine power. Progress became one of these laws as evidenced in the thought of Herbert Spencer. Mandelbaum makes the point that we can see this rhetorical move in Darwin's adoption of Spencer's

[4] Part of Darwin's genius was to reconfigure what progress in evolution meant. It was certainly not a process of linear evolution from lower to higher forms. Darwin's famous metaphor of the branching tree was meant to indicate that so-called higher and lower species existed at the same time and that these designations were a function of their capacity to adapt to their environment and therefore relative. Progress was limited to "intra-branch" movement. And yet, part of what allowed Darwin the freedom to regard lower species as the ancestors of humans were his experiences on the *Beagle* where he encountered indigenous South Americans, peoples who, according to Darwin, appeared more animal-like than human. Witnessing this "savagery," contrasted with bourgeois European respectability, suggested to Darwin that humans were not quite as exceptional as ideas from Natural Theology had suggested (Desmond and Moore, 1991).

phrase "survival of the fittest." Technically, of course, it is "survival of the fit" as those that survive are only "fit" in a particular context. The term "fittest" implies that those that survive are somehow ideally suited for survival. Natural selection, which only operated in a particular context, seems to be "selecting" by some sort of universal or absolute category of viability. Thus it is a bit misleading to say that natural selection was regarded by its advocates as a random process.

While there were, undoubtedly, some aspects of chance involved, its underlying link to progress is what made Darwinism attractive to bourgeois science. There is no question that, at times, this new evolutionary perspective, particularly in its French incarnations, was utilized as a means to critique the social relations of this time. But, in a more general sense, these new time-scales were very much in-line with the new bourgeois world and functioned to stabilize it. It offered a vision of the world that could be changed, but not directly. Later, the possibility of change would be used to sell the poor on the opportunities of liberal democracy while the reality of stasis-the vast timescales within which change took place as well as the futility of human intervention in this process--would ensure that existing social and economic relations remain relatively stagnant.

Chapter Two: Evolution in the Gilded Age

While European nineteenth century thought had embraced the new historicity of knowledge quite broadly, it would have been difficult to predict in the early part of the nineteenth century just how successful evolutionary ideas would become in the Anglo-American World. Like more general notions of evolution in European thought, American evolutionary ideas would remain connected to the growing power of the market-driven world. They too would rationalize and legitimate the new social conditions many in the US were now exposed too, particularly as the population of cities, including the new urban poor, and those working in industry multiplied. Some of these positions would be on the political "right" and some on the political "left," but all would use the growing rhetorical force of science and naturalism to legislate, or at least participate, in questions of value. As I argued previously, the variant of evolution that came to dominate historical thought was a most Malthusian version, though other version were occasionally embraced by socialists and other radicals.

Furthermore, as I will point out, the debates over evolution and the debates over science and science education reviewed in the previous chapter occurred roughly at the same time, taken up by a lot of the same characters. Advocates of science education like John Tyndall, Thomas Huxley and Herbert Spencer were the same men who sought to have scientists embrace evolutionary thought as well. This was more than simply coincidence. While evolutionary arguments were not identical to scientific ones, in many cases they had similar intentions-the importation of a new world-view which was decidedly "secular" (in the strange way that science was "secular"), materialistic, practical and modern. Thus, the debates over evolution were far broader than simply ones about biology, but often reflected a larger set of political a priori's about US society. As with science, the popularization of evolutionary ideas took place in the context of the growing instability of American society, particularly in the 1870s and 1880s where massive and violent strikes crippled various industries every few years, the immigration of non-Protestants challenged the cultural hegemony of the mostly Protestant, white Gentry and the transformation of the US from a mostly agrarian to manufacturing society, including the widespread dissemination of technology, required an explanatory language communicating that these changes were in the service of a larger progressive development. The vocabularies of evolution provided such a language.

American evolutionary thought would be utilized to explain wildly divergent phenomenon, from the natural and biological to the social, political and economic. On the continent, the dramatic upheavals and miserable living conditions experienced by workers would move many people to turn to variants of anarchism and socialism. Conditions were so difficult and so obviously a result of industrialization that naturalizing them through the discourses of evolution, suggesting that they reflected the survival of the fittest and God's plan, was more easily dismissed as an ideological ploy of the commercial classes. In the US, evolutionary ideas were also made popular by those identifying themselves as liberals, even socialists. It was thus able to establish a firmer intellectual basis in the US on all sides of the political spectrum.[1] This was because evolutionary thought was not simply about rationalizing the inequities of free-market

[1] This was also the case in Europe, but for various historical reasons, particularly in France, the dominance of formalism in European thought made the incipient adaptationalism of evolutionary ideas less attractive.

capitalism, though it surely was at times, but it also reflected broader concerns about which structures of US society were to determine question of values. For many embracing evolution, the progressive historicist narrative it implied provided an optimistic temporal perspective by which to analyze and judge US society. Furthermore, evolution played up some of the characteristics which had traditionally divided the new world from the old-a focus on individual achievement, the presence of opportunity and a valorization of the entrepreneurial spirit. Americans had been trained to be suspicious of the communitarian strains in European thought, yet another marker of its incipient authoritarianism, and the vocabularies of evolution provided a sophisticated and scientific language to once again express American exceptionalism.

In many traditional accounts, the early years of evolutionary thought in the US are characterized as a battle between science and religion wherein the latter refused to accept the results of the former because it challenged religious dogma (Draper, 1926; White, 1896). This was only partly the case. The debate over evolutionary ideas, particularly natural selection, masked a larger debate about the role of science in determining questions of value and this is the central argument I will make in this chapter. The so-called battle between religion and science was a contest over the future of ethics in the modern world. Would value be determined by religion and spirituality, seeking to infuse the world with a higher purpose, or science and technology, seeking to refashion the universe on the model of the machine? Of course, this divide is too simple and most thinkers sought to reconcile these positions. And yet, many in religious circles were quite explicit about their repudiation of the seemingly degenerate values that came out of science which appeared to remove all meaning and purpose from the universe. In this chapter, I will distinguish between a broad, general notion of evolution and the particular form it took in the second half of the nineteenth century under the influence of Darwin's *Origin of the Species*, among other works (Darwinism) which, for the most part, was oriented around the idea of natural selection. In reality, many who participated in these debates during these years ignored this distinction and conflated Darwinism with evolutionary thought in general. This is often still the case. As I explained previously, the construction of Darwinism was very much a social and political process which far exceeded the actual writings of Darwin. This is not to say that it was not also a product of the careful study of the natural world. The shaping of the Darwinian and neo-Darwinian doctrines took place in a particular historical context which profoundly shaped its expression. Darwin's earliest sympathizers helped purge his ideas of those which might not achieve bourgeois respectability and Darwin's earliest critics were quick to point these out.

The first major controversy around Darwin's work came in Thomas Huxley's clash with Bishop Wilberforce in June 1860, but was mostly ignored in America because of the Civil War. Huxley, Darwin's "bulldog," was probably most responsible for giving Darwinism its anti-clerical overtones as he used the idea of natural selection in his political battles with the religious old-guard in English society, offering an atheistic reading of evolution. Darwin's other supporters in the scientific establishment-Asa Gray, John Tyndall, Robert Hooker--worked much harder to reconcile Darwinism with Christianity. Besides, by 1860, the dangers of revolution had simmered in Britain and evolutionary ideas, which had once seemed too radical and a threat to the established order, no longer seemed so dangerous, especially in the hands of Darwin's bourgeois colleagues (Desmond, 1991). Even those sympathetic to evolutionary ideas rejected the idea that natural selection could explain the origin of species, particularly in the case of humans (e.g. Georges Mivart). It was not until the development of the theory of the gene in the early part of the twentieth century that natural selection was widely accepted as the primary mechanism for evolutionary change. Darwinism evolved in a context within which the relationship between theology and science was undergoing change. As science competed with religion as a perspective by which to understand the natural and social worlds, it offered its own solutions to some ethico-political issues which theology had mostly dealt with, solutions which were very different and not easy for many to accept. Thus, as I hope to demonstrate in more detail, it is a mistake to characterize debates over Darwinism as ones between science and religion. Even if these were the terms employed in the debates, they disguised a deeper struggle over values.

1. Darwinism comes to America

The popularization of evolution went hand in hand with the reform movement to put more science in schools. Thus, one encounters many of the same figures as in the previous chapter detailing the origins of science education in the US. From 1860 to 1870 articles in the *North American Review* went from describing evolution as "fanciful" in 1860, offering "much to recommend" in 1864, and "one of the great intellectual events of the present century" by 1870 (cited Hofstadter, 1959, p.22). There was recognition, from the beginning, by several leading proponents of Darwinism that this work could be read as a challenge to the received wisdom of Christianity. John Fiske tried to explain why this was not the case and that people of faith could easily assimilate evolutionary ideas into their theologies.

> It is very easy to see what the attitude of the doctrine of evolution is toward [religion]... it asserts and reiterates them both; and it asserts them not a dogmas handed down to us by priestly tradition, not as mysterious intuitive convictions of which we can render no intelligible account to ourselves, but as scientific truths concerning the innermost constitution of the universe-truths that have been disclosed by observation and reflection, like other scientific truths, and that accordingly harmonize naturally and easily with the whole body of our knowledge. The doctrine of evolution asserts... that there exists a Power to which no limit in time or space is conceivable, and that all the phenomena of the universe, whether they be what we call material or what we call spiritual phenomena, are manifestations of this infinite and eternal power (cited in Hofstadter, 1959, p. 55).

Furthermore, for Fiske, evolution worked in the service of righteousness as it only allowed that which enhanced the fullness of life to survive. T.H. Huxley was less conciliatory and regarded Darwinism as a full out assault on Christian interpretations of the origins of life. Writing in a review of Darwin's *Origin* in 1860,

> Deserving no aid from the powerful arm of Bibliolatry, then, does the received form of the hypothesis of special creation derive any support from science or sound logic? Assuredly not much... But the hypothesis of special creation is not only a mere specious mask for our ignorance; its existence in Biology marks the youth and imperfection of the science. For what is the history of every science but the elimination of the notion of creative, or other interferences, with the natural order of the phenomena which are the subject matter of that science? (Huxley, 1896, p. 56-58).

It is not hard to see why many devoted Christians would react the way they did. Leading American Botanist and Professor of Natural History at Harvard, Asa Gray also published a review of Darwin's work (1963). In 1859, Gray had challenged his colleague at Harvard, the last great anti-evolutionist, Louis Agassiz, to a series of debates on the geographical distribution of plants and animals, which Gray explained in evolutionary rather than idealistic terms. Gray published his review of *Origin* in January 1860 in the

American Journal of Science and Arts to make sure his friend Darwin got a fair hearing in the US in anticipation of his debate with Agassiz. Naturally, the review was quite favorable and Darwin himself approved of it and sought to have it published in England. The review pit Agassiz's supernaturalism-the idea that species arose out of a "divine will" and remained the same through generations, though varying slightly from a basic form, against Darwin's naturalism-the idea that species descended from a common ancestor and adapt and are adapted to specific environmental conditions. While Gray characterized Agassiz's notions as "theistic to excess," he was careful to note that Darwin did not deny the role of a "supreme intelligence" or the compatibility of his work with a theistic view of the universe. In fact, Gray regarded Darwin's work as providing "a strong stand against mere naturalism" (Gray, 1963, p.18).

Gray's defense of Darwinism was that a material connection between organized beings was consistent with an intellectual connection between them, as organized by a divine plan. It simply tried to explain the "how" as opposed to the ultimate "why." While he acknowledged that these ideas could lead to atheism, a view which he described as one "which few sane persons can long rest in" (47), he advanced instead that "there is order in the universe; that order presupposes mind; design, will... natural law, upon this view, is the human conception of continued and orderly divine action" (47). Gray continually argued for the consistency of theism and Darwinism. He distinguished between a "scientific" explanation (of which Darwin's work is an example) which was responsible only for dealing with secondary or natural causes and a philosophical or theological one, which explained primary/final causes. As he put it,

> The wiser and stronger ground to take is, that the derivative hypothesis leaves the argument for design, and therefore for a designer, as valid as it ever was; that to do any work by an instrument must require, and therefore presuppose, the exertion rather of more than of less power that to do it directly; that whoever would be a consistent theist should believe that Design in the natural world is coextensive with Providence, and hold as firmly to the one as he does to the other, in spite of the wholly similar and apparently insuperable difficulties which the mind encounters whenever it attempts to develop the idea into a system, either in the material and organic, or in the moral world (145).

In 1874, Gray wrote a defense of evolution against the attack of Hodge's *What is Darwinism* published in the *Nation*. There he argued that if Darwin were to deny the role of a creator, it would be as unscientific as to affirm it. The point was to distinguish between the theological and the scientific, a compromise that would allow science to flourish in a Christian society. This was a strategy adopted by many Christian evolutionists.

2. Evolution and Social Science

In the US, Darwinism was transformed into "Social Darwinism," one of the leading strains of American conservative thought. Historians have tended to debate just how much social Darwinism was a real force and how much of it was simply a label used to caricature or oversimplify an opponent's position in political battles (Bannister, 1979). Making the question even more complex was that social Darwinism, if we define it as arguing for some form of intra-human competition for survival, was taken up by those on the right and on the left. Conservatives utilized the idea of competition to defend the status quo while reformers and socialists utilized it to argue for change. Still, the position itself, in whatever political guise, was conservative in the sense that it held up relations from nature-as expressed by the results of science--to guide social relations. Furthermore, by "professionalizing" these important political debates, that is, suggesting that their grounding in science made them appropriate fodder for experts rather than laypeople, social Darwinist ideas operated to strengthen an elitist, anti-democratic strain in US culture. The idea is not to deny that the idea of a competition for survival was a major force in American thought during the latter years of the nineteenth century, as some have done as a reaction to the complexity of the social Darwinism of this period, but to try to distinguish between its different expressions.[2] Social scientists like Herbert Spencer, William Graham Sumner and Lester Frank Ward were most responsible for offering an intellectual basis for social Darwinism, though from different political perspectives

Although the more conservative strands of social Darwinism were anti-piety, they did adopt a kind of secular/naturalistic Calvinism with a focus on individualism, hard-work, and frugality (Hofstadter, 1959). It is easy to see why this work appealed to so many, particular those in businesses, as it seemed to reflect the conditions of late nineteenth century America. As John D. Rockefeller put it, "the growth of a large business [is] merely a survival of the fittest... the working-out of a law of nature and a law of God" (cited in Hofstadter, 1959, p.45). These positions often had practical implications, usually related to rejecting any sort of government intervention or regulation of the market. For instance, Spencer's work was used by Youmanns to reject the eight hour strikers. Popular

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[2] Much of the criticisms of the idea that social Darwinism dominated American thought in the late nineteenth century are a reaction against Richard Hofstadter's (1959) seminal work, which doesn't always recognize ambivalence about social competition in thinkers like Spencer and Sumner. This is an important correction. However, there is a risk in going to the other extreme, which some of Hofstadter's critics do, and denying that there was a powerful, conservative discourse of social Darwinism during this period. Spencer, who was very much against most government intervention in social affairs, was one of the most widely read authors of his day. This does say something about the force of an idea like "survival-of-the-fittest" during these years. My thesis is that both the more conservative and more liberal variants of social Darwinism depend on a more important conservatism with respect to their veneration of science and naturalism and the consequent de-politicization of value this can engender.

literature took up some of these themes as well including Russell H. Conwell's *Acres of Diamonds* and Edward Bok's *The Young man in Business.* William Matthews, a journalist for the *Chicago Tribune,* produced a series of pamphlets like, *Getting on in the World* (1873), where he offered this advice on how to get rich on America.

> Read the history of the rich and the poor in all ages and countries, and you will find, almost invariably, that the "lucky dogs," as they are called, began life at the foot of the ladder, without a finger's life from Hercules; while the "unfortunates," who flit along life's paths more like scarecrows than human beings, attribute the very first declensions in their fortunes to having been bolstered and propped by others (Cited in Skotheim and McGiffert, 1972, p.19).

The implication was that there was something immoral about government or other kinds of assistance, violating nature's ability to weed out the weak. In 1889, businessman Andrew Carnegie offered his "true gospel of wealth" in which the "law of competition" is raised to an all-embracing principle by which to guide all human existence as it is "the highest results of human experience, the soil in which society so far has produced the best fruit" (ibid, p.40). He goes on. "Unequally or unjustly, perhaps, as these laws sometimes operate, and imperfect as they appear to the Idealist, they are, nevertheless, like the highest type of man, the best and most valuable of all that humanity has yet accomplished." Even most conservatives did not like the ugliness of a competition for survival; many just felt it was inevitable.

Spencer

Some of the fundamental ideas of social Darwinism were laid out by Herbert Spencer years before Darwin published the *Origin of the Species.*[3] Herbert Spencer's all-

[3] Thus, the term social Darwinism is a bit misleading. Still, Darwin's distaste for the reformers of his time and his eventual adoption of Spencer's phrase, survival-of-the-fittest, suggests that this variant of evolutionary ideas were not completely adverse to him.

embracing theory of evolution found much success in the US. Spencer's *Synthetic Philosophy* (1882) appeared in the US in a series of volumes after 1860. Spencer's thought dominated American thought from the demise of transcendentalism to the rise of pragmatism. Spencer's *The Study of Sociology* (1874) had a tremendous influence on early sociology, especially on Ward, Cooley, Giddings, Small and Sumner. The sale of Spencer's work was unparalleled for works of philosophy and sociology.

Spencer's inspiration came from the ideal of cooperative individualism of his youth, favoring the voluntary-like organizations of early industrial towns (Ross, 1991). For Spencer, all thought had to be organized around the concept of evolution, around the processes, which all things undergo, of differentiation and integration. All things in nature "develop" or "evolve" by forming new, increasingly complex and differentiated unities. This principle can be extended from the biological to the cultural and moral. Spencer was originally trained as a Civil Engineer and some of his early observations in hydrotechnics and population theory inspired his idea of evolution and the conservation of energy (Hofstadter, 1959). Spencer took up diverse ideas: development from Lamarck, Von Baer and Coleridge; energy theories from Helmholtz, Joule and Kelvin and social principles from Malthus, combining them into a monolithic system. His social theories were always special cases of more general principles. In a sense, Spencer was the culminate expression of nineteenth century naturalism's wish to apply the laws of nature to social thought.

The main ideas of Spencer's system included the "persistence of force," the idea that matter was continuously undergoing evolution and dissolution and "evolution," the processes by which life changed from an incoherent homogeneity to a coherent heterogeneity, culminating in "equilibration," a state of equilibrium achieved by animals or society. The principle that the homogenous will inevitably develop into the heterogeneous due to the persistence of force, and thus, the instability of the homogeneous, was the fundamental law of universal evolution as was the inevitability of equilibration. In the case of society, it resulted in a state of great happiness and perfection. Spencer's system offered a compromise to the religious in America by admitting that science was limited in the face of an Unknowable. Spencer's social theory took these ideas and argued (ala Malthus) that the pressures of survival led people to adapt using technological innovation and other means and thus select the best of a generation to survive. For him, mental evolution meant (ala Lamarck) that these mental advances could be inherited and humans could become progressively smarter.

His first work, *Social Statics* (1850) recognized the moral implications of this and tried to derive a theory of ethics, a defense of *laissez faire* through biology. It was intended to reject the Benthamite stress upon using legislation for social reform. Spencer called for natural rights as an ethical standard. The State exists, for Spencer, to make sure people's freedom to do as they please is not curbed. As the root of evil is not adapting one's constitution to one's conditions, it is in the very nature of the organism to adapt and evil tends to disappear; human perfection is necessary as humans adapt a new moral constitution for civilized life. This sometimes led him to a harsh conservatism where he could say, for instance, "if they are sufficiently complete to live, they do live, and it is well they should live. If they are not sufficiently complete to live, they die, and it is best they should die" (Spencer, 1865, p. 414-415). He opposed all government intervention in education, banking, housing, sanitation, medicine, etc. He did, however, point out that he was not opposed to voluntary charity as it elevated the donor's character and helped to develop altruism. In *The Principles of Sociology* (1967), he likened the development of society with the development of the organism, leading society to culminate in an "industrial" form where a new human nature emerged which was capable of solving all ethical problems. Spencer's sociology would point people to the enormous complexity of the social organism and blunt the power of reformers who saw simply cause and effect relationships. It would demonstrate that transformation could only take place slowly and not, as is sometimes asserted, that transformation does not take place at all.

Sumner

William Graham Sumner of Yale picked up some of the more conservative aspects of the social Darwinist doctrine, though his views were not as straightforward as critics of his work sometimes argue (Bannister, 1979). He was a professor of political and social science at Yale from 1872 to 1909 and was the leading exponent of a pessimistic variant of evolutionary theory which argued against intervention in social structures. Sumner's work of the 1870s and 80s focused on his tirades against reformism, protectionism and socialism, but by the 1890s, as many began to reject his out and out anti-reformism, his focused shifted to academic sociology. He was influenced by Spencer's *Study of Sociology* and was galvanized by the violent railroad strikes of 1877. For him, survival was a result of strength and evidence of virtue. The future of society depended on the success of the selection process, especially, as Malthus had suggested, in the case of overpopulation. For him, it followed that the capitalists were to be rewarded through huge wages for their bringing efficient management to society. Similarly, equality as an ideal was rejected as "there can be no rights against Nature except to get out of her whatever we can" (cited in Hofstadter, 1959, p.59). So too was the ideal of a democracy, which he referred to as the "pet superstition of the age." As far as government intervention, he rejected it virulently: "Let every man be sober, industrious, prudent, and wise, and bring up his children to be so likewise, and poverty will be abolished in a few generations" (ibid, 61).

Unlike Spencer, though, he did support public education. Sumner regarded schools as a means by which to protect society from government meddling and control the masses. He was generally critical of the education of the 1890s, "In truth half-culture is one of the great curses of our time. Half-culture makes men volatile and opinionated. It makes them the easy victims of fads and fallacies and makes them stubborn in adhering to whims which they have taken up" (ibid, 230). Sumner did, however, allow for scientific government intervention because statecraft could be guided by "active reason" and "intelligent conscience," especially when it came to preserving competition (Bannister, 1979). He even allowed that democracies need to train voters so that they can make adequate technical judgments.

Sumner regarded progress as the result of technological innovation, which, in turn, bred social and political change. Such progress was disrupted when social relations were purposefully tampered with, especially in the way of attempts at political reforms. With respect to this, reforms in the name of democracy or equality can be the most devastating. Sumner's fear was particularly intense when it came to state regulation of capital or industry. He felt that such reforms would inevitably politicize business--which he felt was, in itself, not political and would lead to a wealth-based plutocracy. This points to a complexity in Sumner's thought, he rejected reformism but, at the same time, hardly wanted to see a society dominated by capitalists. Sumner's social Darwinism regarded the independent, self-made, small businessman as the forgotten figure, yet culmination, of nineteenth century America, a society whose future depended on these individuals. These individuals were ignored by a system dominated by big capital. Sumner distinguished between a struggle for survival against nature and a struggle for survival between humans, arguing that it was the first that should not be tampered with and not the latter. Still, as far as the rich, they are "a product of natural selection, acting on the whole body of men to pick out those who can meet the requirement of certain work to be done" (cited in Hofstadter, 1959, p. 157). While he sought to develop a science outlining the laws of society so that the consequences of social action would be better understood, in the end, he assumed this science would limit these kinds of interventions. Sumner was a virulent critic of all socialist thought, referring to it as a sentimental philosophy, arguing that in its desire to redistribute wealth, it would destroy a far more important component of society--liberty. For him, socialism retarded the survival of the fittest, the essential ingredient of social progress as it tries to shorten a process which should take centuries into a lifetime (Sumner, 1952).

Ward

Lester Frank Ward was also influenced by Spencer and developed a comprehensive sociology in his *Dynamic Sociology* (1883). However, against Spencer and Sumner, Ward distinguished sharply between physical or purposeless life and human evolution which could be modified by human intervention. Ward's work was mostly ignored until the turn of the century and in 1906 he was elected first president of the ASS. Ward's democratic ideals were offended by the social Darwinism of the late nineteenth century. Aside from Sumner, Ward's thinking was influenced by his brother, Cyrenus Osborne Ward, a labor radical and communist. In his early work, Ward argued that government collected statistics could be used as data for more science-based lawmaking. While natural-law and *laissez-faire* doctrines made sense as society tried to free itself from monarchy and oligarchy, they no longer did in an age of representative government wherein the people's will was enacted. It was only through the artificial control of natural phenomena that science could be used for the benefit of human needs; in fact, he argued, competition actually prevented the most fit from surviving. Social science must help in "the improvement of society by cold calculation." In order for a society to be capable of this kind of "dynamic action" education for all was key. This is why he objected to Weismann's rejection of the inheritance of acquired characteristics, it dulled the effect of education. Even if nature had no purpose, human action did.

Ward believed that progress was not inevitable and that it was possible to exercise deliberate social control over institutions and society. This progress was to be guided by a moral and ethical vision. Because all social institutions were the product of people's intellect and deliberate human action, cold calculation could alleviate all suffering. Scientific education could be used to control social development as the path to happiness and progress, through "dynamic action," which in turn depended on accurate knowledge and the dissemination of scientific truths. Ward too put his faith in science to guide social reform, and more generally, accepted that scientific rationality could overcome any social problem or contradiction. For him, as for many in his generation, scientific control guaranteed the kind of order divine control had offered in earlier centuries.

Science was to be used to ameliorate social conditions. This, "science of human life," or sociology, was utilitarian in that it focused on what is good for people. This meant that science was not value-neutral.

> All science is essentially ethical… Social science is more so than all other science only because it deals more directly and exclusively with the collective welfare of mankind. It seeks not merely to reduce the social friction and thus accomplish all that old ethics has so vainly striven to secure, viz., negative moral progress, but also chiefly to put the manifold existing and prospective wants of mankind in the way of satisfaction, and thus to bring about a progressive and unlimited train of benefits and a truly scientific or positive moral progress (cited in Hofstadter, 1959, p. 87).

Ward was critical of evolution as an overarching, a priori, moral principle--"He [humans] proceeded to interrogate nature at all points, and the thousand conflicting and commingled answers that he got, all rolled together, when closely listened to, were found to spell out the talismanic word: "Evolution" (1883, p.543). Although Ward accepted some of the basics of Spencer's evolutionism, he rejected Spencer's a priori assumption that only the "survival of the fittest" could improve social conditions. Unlike Comte, Ward went on, Spencer missed that organic and social evolution were not the same thing and were not governed by the same laws. Because of the power of thought, humans could shape their world. Humans were not passive victims of nature, but active. Dynamic social forces controlled by human effort through the use of mind could help human societies reach a higher stage of development. Ward reserved his most passionate critique for the doctrine of *laissez faire*.

> Why cry "Laissez Faire!" as if society would ever work out its own progress? As well say to all inventors: Cease trying to control nature, let it alone and it will control itself; it will, if left undisturbed, work out, in its own good time, all the cotton-gins, reaping machines, printing presses and sand blasts that are needed (Ward, 1885, p. 53).
>
> No progressive race has ever been content with the natural. There are philosophers who cry "laissez faire!" but every step man has taken in advance, every invention he has made, all art, all applied science, all achievement, all material civilization, has been the result of his persistent refusal to let things alone" (ibid, p. 309-310).

Ward recognized how inconsistent people were with this doctrine, particularly business. For someone like Sumner "...Laissez fare is "translated" into "blunt English" as meaning "mind your own business" (cited in, Commanger, 1967, p. 66]. Instead, humans must develop a kind of collectivism as,

> The true function of government is not to fetter but to liberate the forces of society; not to diminish but to increase their effectiveness. Unbridled competition destroys itself. The only competition that endures is that which goes on under judicious regulation" (ibid, p. 313).

Society must become a "sociocracy" where collective, socialized action is used to direct social forces and increase the quality of people's lives. As Henry Steele Commanger (1967) points out, Ward was the first to articulate the idea of the modern welfare state.

What is required for a sociocracy is education--the "great panacea." As Ward put it in *Dynamic Sociology,*

> The diffusion of this kind of knowledge among the masses of mankind is the only hope we have of securing any greater social progress than that which nature itself vouchsafes through its own process of selection... Of all the panaceas that have been so freely offered for the perfectionment of the social state, there is none that reaches back so far deep or out so broad as that of the increase and diffusion of knowledge among men... The great social duty, therefore, is the universal diffusion of all the most important knowledge now extant in the world (cited in Commanger, 1967, p.461).

In Ward, as will also be the case in Dewey, one finds the basics themes of a critical education, one that views knowledge as part of a path to self and social growth. And yet, similarly, both will blunt the full radical-ness of their positions by an appeal to scientificity.

The Darwinist "Left"

Over the course of the late-nineteenth century, a more liberal version of social Darwinism began to develop which sought to rescue evolution from some of its most anti-Malthusian critics. Darwin himself argued that man's moral sense was critical for group survival, an idea developed further in Kropotkin's (1902) *Mutual Aid.* Similarly, Huxley tried to distinguish between "fit" and "best" in order to reject that idea that only the "best" survive, insisting that man and nature make different judgments of value. He argued that the more advanced a society becomes, the more it could eliminate the struggle for existence as a factor. Benjamin Kidd, in his *Social Evolution* (1894), combined Darwinism with Christianity, arguing that humans needed a super-rational sanction like religion (and not socialism as it would abandon competition-an issue a lot of these books addressed by the 1890s).

By the end of the century the social gospel movement attacked industrialism and the excesses of social Darwinism from a Christian perspective. Many social Christians were most affected by the nascent conditions they found in urban environments and combined reformism and evangelicalism, hoping to help the urban poor by making cities more livable, and also, if they were lucky, bringing them salvation. This was the initial approach of the Salvation Army though it gradually focused more exclusively on social services. Religious critics of the social gospel would argue that they were too focused on life in this world rather than the world-to-come (Philips, 1996). Though some in the social gospel expressed concern over the plight of blacks in the US, they generally did not speak out on their behalf. However, what little work they did do was influential in the eventual formation of the Civil Rights movement. For instance, social Christian, Samuel Chapman Armstrong was a founder of the Hampton Institute, the school that would graduate Booker T. Washington. Armstrong helped Washington become principal of the Tuskegee Institute. Years later, another school set up by social Christians in the South, Morehouse, would graduate Martin Luther King Jr. (Lucker, 1991).

Social Christians developed a full-blown reformist theology. Evolutionary ideas figured prominently into their thinking, particularly the more optimistic variants of the doctrine of progress. Washington Gladden's *Applied Christianity (*1886) and Lymon Abott's *Christianity and Social Problems* (1896) were critical texts in this movement and they generally appealed to changes in character as a cure for social ills. They supported increased government regulation. Both authors worked hard to distinguish themselves from socialism which put, as Gladden put it, the environment rather than character first. Their politics tended to be liberal and they preached voluntary social reform and charity. They tended to advocate vocational education, not for jobs but for character. Many social Christians had been affected by naturalism and evolution and thus were open to considering more liberal theologies as well as politics. Gladden spoke of a "social salvation." Most objected to the idea of a free competitive order. Gladden, fearing that the poor would rise up and attack the competitive system, urged "industrial partnerships." Coming a bit later was Walter Rauschenbusch's *Christianity and Social Crisis* (1907) which urged US society to refigure its moral base along collectivist lines. Rauschenbusch argued that even Christ's work had to be regarded along evolutionary lines, its lessons changing as society changed. Many of these social Christians went on to shape the Progressive movement (Philips, 1996).

US socialists were sympathetic to Darwinism as well. Both Marx and Engels believed the Darwin had helped assert a scientific and naturalistic basis for their historical materialism. While many socialists rejected some of the Malthusian variants of social Darwinism, they embraced the concept of progressive evolution, as expressed in Spencer's philosophy. The vocabularies of evolution were part of a larger embrace of scientism in this period. By articulating their politics through evolution and science, socialists hoped to capture some of the intellectual influence and popularity of these ideas (Pittenger, 1993). The resulting scientism, however, limited the scope of socialist critique and provided opponents with an easy way to reject their ideas--point to the poor science involved. Much of these issues were captured in the generation of socialist writers doing their work in the 1880s and 1890s which tried to depict what a future socialist state might look like, work like Laurence Gronlund's *The Cooperative Commonwealth* and Edward Bellamy's widely read utopian novel *Looking Backwards*. By the turn of the century, reformist Edward Bernstein adapted evolution to fit his Marxist-inspired *Evolutionary Socialism*. Some on the Left went further and embraced the eugenic ideas of Galton and others, hoping that science could engineer a more just society. In the case of both the social Christians and the socialists, non-Malthusian Darwinism provided an optimistic theory of social change which challenged the hegemony of Malthusian in Anglo-American evolutionary thought. However, in both cases, the Darwinism and incipient scientism ultimately dulled the force of their criticisms by setting a priori limits on possible paths for social transformation and was too easily co-opted by the more conservative political thinking of the time.

In the US, evolution, although couched in the languages of natural science, came to reflect a particular ethico-political perspective on the America of the Gilded age-one that would, at times, be used to rationalize the inequities of capitalism and at other times be used to try to attack those inequities. Both positions used the scientificity of Darwinism to their advantage. The more conservative strains usually tended to be more Malthusian in focus and the liberal ones more Lamarckian. Both these positions seemed to venerate "science," making it vital to political and moral questions. By late century, Darwinism would be mobilized to support racist ideas around the inferiority of the new groups of immigrants. Even Ward, whose politics paved the way for the kind of progressive thought which would dominate the American political landscape in the early years of the next century, was a proponent of "negative" eugenics and employed evolutionary ideas in this way. In fact, while the political winds had shifted dramatically by the early part of the twentieth century, evolutionary thought was just a popular among leading progressive thinkers. The consequence of its popularity was less support for an explicit "political" position and more an implied politics on the relation of science to society and questions of value.

3. The Christian Response to Darwinism

Before questions around evolution divided the Protestant communities, the new Higher Biblical criticism challenged some of the foundations of American Protestantism. While the Medieval Church accepted that parts of the Bible were allegorical and were subject to interpretation, beginning with the Reformation, as ordinary people began to read the Bible, more and more Protestants came to insist that the Bible be taken literally. In the United States, biblical literalism was widespread in the periods of Great Awakening (1740-1745, 1800-1815) and seemed to relate to the democratic spirit of US society (Szasz, 1982). "The Bible is a plain book, addressed to the common sense of man," said a minister in 1851, "and the arrogant pretense that the common people cannot be trusted with its mysteries is an insult to its author" (cited in Szasz, 1982, p.16). Over the course of the nineteenth century, scholars in Germany began to use the methods of comparative linguistics and textual analysis to analyze the Old and New Testaments. First termed *Graf-Wellhausen* after Julius Wellhausen, analysis of the Old Testament, according to these critics, suggested that it was penned by several different authors and that some of its accounts could not be taken as historical ones. Although David Strauss's influential *Life* *of Jesus* was available in English by 1846, it was really after 1880 that American Protestants began to seriously debate the problem of the new biblical criticism. The key point is that the economic and political context of the post-antebellum period precipitated a crisis in Protestant America and the logic of American exceptionalism it valued, a logic guided by a kind of ecumenical salvationism which regarded America as God's kingdom on Earth. It was a crisis from which American Protestantism would never fully recover.

While liberal Protestants tended to argue that biblical criticism was grounded in science and scholarship-and thus more reliable than the Church's position, as well as able to provide analysts with a "deeper" sense of the Bible--conservative Protestants argued that because the Bible was the word of God it could not be regarded as erroneous, in any sense. Further, they pointed out that biblical critics frequently contradicted each other in their own interpretations of scripture. Finally, the most vocal critic of the higher criticism, T. Dewitt Talmage, warned that by suggesting that stories in the Bible were not necessarily true, liberal Protestants were blaspheming Christianity and undermining its teachings (Szasz, 1982). As would become the case with the debate over evolution, the debate over higher criticism pointed to a major cleavage in Protestant theology--who was better capable of making sense of the Bible and religious ideas in general, expert/scientists or common people.

Every major outlook in late nineteenth century America had to deal with evolution, including Protestant Christianity. Naturally, there was no uniform Christian response to Darwinism and different parties regarded the hegemony Darwinism came to hold in the scientific world differently. According to Jon Roberts (1988), at first, Christians tended to refute Darwinism in scientific terms, as had been their practice with any scientific theory that challenged received biblical wisdom, many taking up the criticisms of Darwin by scientists like Henry Charles Fleeming Jenkin and St. George Jackson Mivart, particularly as related to the problems with the doctrine of transmutation. But gradually, as some Christians realized what was at stake in this debate and Darwinism became more and more widely accepted in scientific circles, particularly after 1875, the challenges became more theistic in character. There can be no doubt that evolution played a part in a certain kind of secularization of American intellectual thought. There can also be no doubt that evolution contributed to a shift in the relationship between science and theology. One of the consequences of evolutionary ideas, though it would only be completely felt in the early part of the twentieth century, would be to violate the compact science had made with theology in the sixteenth and seventeenth centuries (as articulated by Galileo, Descartes and others) that science would limit itself to explanations of nature and theology would concern itself with human and particularly moral matters. Evolution, whether explicitly or not, imported its own sense of value which ran in contradistinction to some values long held by the Christian world and, particularly in its social Darwinist guise, allowed science to extend its domain. This move set the stage for some of the tension between science and religion, still many resent analyses are correct in their recognition that there was no all out "conflict" or "war" as is implied by titles of works written in this period like A.D. White's (1896) *A History of the Warfare of Science with Theology in Christendom* (Roberts, 1988; Young, 1985). This also does not mean that the scientific community embraced Darwinism uncritically. Many were still dissatisfied with

Darwin's account of the operations of transmutation and it was only with the establishment of the "modern synthesis" in the next century that the bulk of scientists accepted natural selection as the primary mechanism of evolution. Still, this did not prevent them from embracing the idea of evolution or transmutation as a whole but it did allow Protestant critics a "scientific" means by which to refute Darwin's least appealing ideas.

In 1880, the editor of an American religious weekly estimated that from one-quarter to one-half of the educated ministers of the leading evangelical ministries believed that "the story of the creation and fall of man, told in Genesis, is no more that record of actual occurrences than is the parable of the prodigal son" (Numbers 1992, p.3). Evangelicals had been were much more accommodating to Darwinism in its early years than one might think. Christian Geologist, John William Dawson, in his *Story of Earth and Man* (1873), insisted that all things were produced by a creator but accepted that this "does not even exclude evolution or derivation to a certain extent" as "anything once created may, if sufficiently flexible and elastic, be evolved or involved in various ways" (cited in Roberts, 1988, p.10). Princeton's James McCosh then urged Dawson to join the faculty because he was the only reputed geologist who was not a Darwinian. It was only about 1875 or so that Protestant ministers began to seriously debate Darwinism, particularly after the ethic-political world view it imported became more apparent and O.C. Marsh could convincingly argue that "to doubt evolution is to doubt science" (cited in Roberts, 1988, p.85). In 1879, Alfred Russell Wallace supplied Protestants with much needed ammunition in his "The Limits of Natural Selection as Applied to Man" where he rejected the idea that natural selection could explain the origin of human consciousness or morality and became increasingly concerned with the social problems engendered by the excesses of industrial capitalism. To which Darwin's *Descent of Man* can be seen as a reply.

Darwinism established a conflict for evangelicals who, up to that point, had accepted the verity of Baconian science inherited through Scottish "common-sense" philosophy. James McCosh argued that Darwinism and the Bible could be reconciled without violating the "common-sense" principle that God created human beings. Anderson of Rochester offered a compromise as well--Christians could regard evolution as God's plan but not as "pure chance." However, he went onto say, evolution was not a "verified law" but an "unverified working hypothesis," one which was indispensable for the progress of science but should not be confused with scientific fact (Roberts, 1988). In fact, many Christians in the scientific world worked hard to distinguish between theory and fact when it came to evolutionary ideas. While facts were unassailable, theory was the result of human interpretation of fact, and could therefore be wrong. Thus, the anti-theistic implications of certain evolutionary ideas were only interpretation and not fact. While some in the religious community contended that if the facts of nature and the facts of the Bible were to come in conflict, the facts of the Bible were to win out, others agreed that one's understanding of the Bible also relied on interpretations by humans and was thus subject to error.

Darwinism threatened the argument from design which had argued that harmony and balance in nature was a sign of God's work, an argument that had been a standard proof of the existence of God. Charles Hodge's influential *What is Darwinism* (1874) expressed the key problem: Darwinism and atheism are the same. As proof of this, Hodge cited the huge number of Christian opponents who embraced Darwinism even if they had rejected earlier forms of evolution. Even though Darwin had attempted to leave room for the divine in his work, for Hodge, a denial of design in nature was a denial of God. Because American Protestantism had embraced empiricist science as a way to augment the authority of scriptures, the widespread acceptance of Darwinian ideas in the science community posed a particularly difficult problem. American Protestants had long regarded the idea that God created each species separately as basic to their conception of the creation of life. As one clergyman put it,

> the production of new forms of animal and vegetable life must be regarded, as it ever has been, as the highest and most astonishing exercise of creative power; and if that power can be supposed to reside in the laws of nature, it seems to us that there is no phenomenon in the universe that will require a higher power: and we are reduced at once to materialism and atheism (cited in Roberts, 1988, p.14).

Here, there is a kind of drawing a line in the sand. If eighteenth and nineteenth century geology had succeeded in removing the divine from the creation of the earth, Darwinism would now do so with respect to the creation of life. For many, this extended the naturalism of the sciences too far and irrevocably restricted the domain of theology. Science, they argued, should stick to what it is supposed to do, compile, classify and analyze data. As this idea suggests, opponents of Darwinism were, by no means, opponents of empiricist science.

Huxley's widely read attacks on Christianity and his notion that the progress of science involved the elimination of "divine" explanations and their replacement by naturalistic ones confirmed that science was in the process of extending its reach. A similar argument was made by John William Drapers *History of the Conflict between Religion and Science* (1874). He argued, famously laying out the terms of the science-religion conflict,

> The history of science is not a mere record of isolated discoveries; it is a narrative of the conflict of two contending powers, the expansive force of the human intellect on one side, and the compression arising from traditionary faith and human interests on the other.

Furthermore, as many Protestants argued, the order that had once been identified in Nature as proof of the Divine was now regarded as a wasteful and ruthless process of selection. What does this then imply about the creator of these processes? What kind of God was this? Hadn't the Bible explained that God created humans in his own image? And finally, what was to become of the Christian idea of an immortal soul if humans evolved from animals by natural processes? Darwinism challenged some of the most cherished ideas of Christian theology. Furthermore, there was no question in the mind of many Protestants that Darwinism sought to replace the principles of Christianity with its own value system, and, as Daniel R. Goodwin put it, "when such a theory is inconsistent with the principles of Christianity or Theism, no matter though it may be disguised in a scientific form, and may bristle all over with scientific terminology, we feel authorized, without any special scientific training, to attempt an exposure of its fallacious and groundless character" (cited in Roberts, 1988, p.41). Much of the debate over Darwinism, particularly after 1875, concerned these moral questions.

The publication of the three-volume, *Life and Letters or Charles Darwin* in 1887 confirmed what many in the Protestant community had long suspected, Darwin's exclusion of the divine from the organic world eventually destroyed his own belief in God. Many opponents of Darwinism used this as proof that Darwinism really was atheism, as Charles Hodge had argued several years before. Upon reading this work, Noah Porter, a supporter of evolutionism, changed his mind about Darwin and argued that Darwin's work offered a "theory of atheistic evolution" (cited in Roberts, 1988, p.106). He went further, by insisting that human thought had simply evolved from animal life, how could we trust the fruit of human thought-science? Porter explained that "if we do not assert for man and the thinking of man its appropriate authority, then science itself should bow off the stage" and predicted that people would not be "quick to receive a philosophy that teaches them that the right of the strongest is the only right which nature sanctions" (cited in Roberts, 1988, p.106, 116).

To nineteenth century America, Darwinism was not simply science but a mode of existing in and understanding the world. Many apologists for capitalism seized the vocabularies of Darwinism to explain why the rich were getting richer and the poor poorer. Only towards the end of the century were the voices opposed more vocal. Some of the first to recognize the problems with this were Christians. Often, their rejection of Darwinism was a rejection of the moral implications of a competition for survival rather than a wholehearted rejection of science or the possibility of transmutation. Often, they worked hard to integrate basic ideas of evolution into their theology. The metaphor of "warfare" between science and religion pushed others to see these critics as dogmatic, mindless, religious zealots. Many in the religious world recognized the changing moral fabric of US society and didn't like it. I don't want to go as far as saying that these Christians developed a full-blown critical evolution, but they did undoubtedly develop a certain critique of evolution. Some of the most ardent supporters of Darwinism tried to tone down the rhetoric of competition. Perhaps, in hindsight, one can agree that blaming evolutionary ideas for the excesses of capitalism or the changes in American morality was a bit short-cited. And yet, as I noted, the intimate relationship between Darwinism and certain forms of proto-capitalist thought makes this slippage not so farfetched. Unfortunately, it allowed many thoughtful critiques of the new economic and political order to be reframed as anti-scientific when quite a few were far more complex than that.

Highlights of Argument-II

Period	Post-Antebellum 1865-1900	Progressive 1900-1917	Cold War 1945-1971	Globalization 1972-2003
Theory of US	Industrialization, growth of poor, create crisis for Protestant Gentry	Immigration, Migration and Urbanization inspire reform movements to "protect" US democracy		
Instrumental Science	Science is professionalized; marked as technological and modern	Science becomes tool of political and educational reforms; sign of freedom/ democracy		
Schooling	Compulsory Schooling requires a modern curricula	Schooling is used to "Americanize" new immigrants and train future workers		
Science Education	Entry into US public education	Laboratory becomes important for doing "real" science; science for vocation		
Dominant Discourses of Evolution	Contest between selectionism and acquired inheritance	Evolutionary Synthesis: hegemony of gradualism and selection		
Critical Science/Education	nature study; classical, liberal, and broad curriculum	Dewey's vision of education as art and as reflective experience		

Critical Science Education/Evolution	Nature Study as means to appreciate the nonhuman world; Lamarckian Socialism	Dewey's vision of science education as reflective experience; revival of Formalism in D'Arcy Thompson		
Educationalization of Science/ Scientization of Education	Science uses education to spread its influence	Education uses science in the form of testing, research and bureaucracy		

Third Interlude: Dewey and US Liberal Democracy

In turn of the century America, the model of democracy inherited from the Greek *polis* and the small towns of New England was becoming less and less viable. The Founding Fathers of the American Republic, who had generously given the right to elect representatives to some but not all citizens, were no friends of populist or participatory democracies. They, no doubt, would have been frightened by the influx of non-Protestant, non-middle class, non-white, non-English speaking immigrants, and newly enfranchised blacks voters, some of whom were part of an agitated industrial labor force. The changing conditions of US society required a changing conception of US democracy. While notions of American exceptionalism required that the vote continue to be extended to the masses, fear of the *demos* required that some of the other structures of US society be utilized to help train the people in the art of being American, and invariably, keep them from radicalizing. The old Protestant gentry could point to many instances of what could happen to their democracy without such training-the corrupt urban political machines manipulating the immigrant vote, the out-of-control, money grubbing robber barons and the generally unsanitary and unsightly living conditions of the urban poor.

As I will argue in this interlude, science, education and science education would all be taken up in one sense or another in the project of updating the structures of US democracy. The progressive movement in education, along with progressive political reforms in general, was probably the most important in this process. The progressive period in American history established a key link between science and democracy, which would be consistently taken up in educational discourses from then on. Science was to be an expression of freedom on the intellectual plane, while democracy would be such an expression on a political plane. The kind of patterns of consumption and spending which capitalism brings would further offer this freedom on a material plane. As with science and education, the image of American democracy and the reality of a market-democracy were often in tension with each other. The best place to see this tension as well as to understand how democracy, science and education were brought together to deal with the new conditions of turn-of-the-century America is in the work of the great American philosopher and educational thinker, John Dewey. In Dewey, one can clearly find a conception of critical education and critical science, though, as I will argue, his scientism and uncritical conflation of democracy-in-general--particularly in its idealized Greek forms--with US liberal-democracy made it almost impossible to put these into practice.

Dewey's work was part of a larger, "revolt against formalism," as Morton White (1949) has termed it, whereby the idealistic and abstract notions of European philosophy were rejected in favor of a more "pragmatic" or experience-based, process-oriented science. It is incorrect, however, to see Dewey's work as wholly oppositional to continental thought. Dewey's earliest work retained elements of post-Kantian thought (i.e. its concern with a totality) expressed as a critique of associationist psychology in his famous attack on the concept of the reflex arc (Dewey, 1963). For Dewey, the dissection of thought into the bits and pieces of a "reflex arc" was an exemplar of the kind of "mechanical" thought he would spend much of his life fighting. But, his conflation of liberal democracies with anti-mechanical and anti-dogmatic thought in general, that is, his inability to really question whether political democracy was possible in a market economy, would stunt the force of his social and educational criticism. However, White is correct in his claim that Dewey's "revolt against formalism" was a rejection of what appeared to be the remoteness of philosophy. In this sense, Dewey's move is important. However, the practical nature of US society would push Dewey's "instrumentalism," and even at times Dewey himself, far further into a vulgar practicalism than was originally intended.

When it comes to American educational thought, one can easily regard Dewey as the most important American thinker of all time, although it is true that most of his complex educational theories were oversimplified and distorted in the writings and practices of many progressive thinkers and schools. It is not only that his ideas were so well thought through and developed, they were, in fact, part of a larger philosophical system, but that evidence of the influence of his basic ideas with regard to education can be found in most classrooms in the US today (no doubt, in reductive and shallow forms). Dewey's wrote three important works on education, *The School and Society* (1900), *Democracy and Education* (1916) and, *Experience and Education* (1938). *The School and Society* was written during Dewey's tenure at the University of Chicago where he had opened his own school in which new educational theories could be tried and tested.

Dewey sought to utilize education to preserve what he regarded as the positive aspects of pre-industrial societies--contact with objects and a sense of personal responsibility--with the progressive elements of the modern world. However, unlike modern society where labor was performed for the sake of the product, in schools, education would take place for the sake of the process. Dewey sought to tame the excesses of capitalism. A further step in this direction was to distinguish between formal and real freedom, the former being freedom from constraint while the latter reflecting the freedom for intelligent self-control. If capitalist societies did not fully offer the latter sense of freedom to children, Dewey proposed, perhaps schools could (White, 1949).

Dewey opens *The School and Society* with an explicit recognition that the new industrial democratic society of turn-of-the-century United States requires a new understanding of education. This is because pedagogy and curriculum must always adapt themselves to the larger social situation within which they operate. Dewey termed these new understandings of pedagogy and curriculum the "new education." In the "old education" the idea of "discipline" was dominant, order was crucial, silence was necessary, schools were set apart from society and children learnt through passive listening, abstract lessons, and recitations. In the new education things are different: children learn spontaneously (or through "directed spontaneity"), actively, and through social cooperation. The school is part of a child's habitat and part of society. The product of education is subservient to the process. Schools no longer provide "practical devices or modes of routine employment… but [are] active centers of scientific insight into natural materials and processes, points of departure whence children shall be led out into a realization of the historical development of man" (19). The school is connected with the rest of the life of the child and becomes a miniature community so that experiences created in school can be carried over to the rest of her/his life and vice versa.

In contrast to the case in the old education, the ecology of classrooms must be arranged so that children can be active with a "workshop, laboratory, the materials, the tools with which the child may construct, create, and actively acquire" (32). In the old classrooms children are treated as a mass, but in the new classrooms they are individuals and "the moment children act they individualize themselves; they cease to be a mass and become the intensely distinctive beings that we are acquainted with out of schools." (33). Similar to the organization of space, education cannot be "one-size-fits-all," in Dewey's terms, a uniformity of method and curriculum, but must make the child its center of gravity. Dewey explains in a much cited section,

> Now the change which is coming into our education is the shifting of the center of gravity. It is a change, a revolution, not unlike that introduced by Copernicus when the astronomical center shifted from the earth to the sun. In this case the child becomes the sun about which the appliances of education revolve; he is the center about which they are organized (34).

Child-centered education also distinguishes itself from the older kinds of education in that it accounts for the principles and processes of child development, derived from the most recent results of modern psychology, which according to Dewey, generally highlight the importance of "social," "developmental," and "emotional" factors in learning. This is so that children can learn more effectively, in ways that are developmentally appropriate. In fact, schools can become laboratories where educational psychologists can come to better understand these principles and processes. Most importantly, and this is the heart of child-centered education, modern psychology suggests that children's connection with the objects of learning be direct (hence, the value of "direct observation" and why good learning is often described by Dewey as "scientific") and that students' motivation for learning be derived directly from their own experiences. The principal job of the teacher in this framework of education is to shape a child's experiences so that the child is furnished with "motives and make his recourse to them [tools of thought] intelligent, an addition to his powers, instead of a servile dependency" (113) and create experiences where children are lead to the problem on their own "...so that he is self-induced to attend in order to find out the answer" (149). Otherwise,

> the child approaches the book without intellectual hunger, without alertness, without a questioning attitude, and the result is the one so deplorably common: such abject dependence upon books as weakens and cripples vigor of thought and inquiry, combined with reading for mere random stimulation of fancy, emotional indulgence, and flight from the world of reality into a make-believe land (112).

Here Dewey introduces the antithesis of child-centered education, the ultimate consequences of the old education, a condition Dewey will reference over and over again in his writings, a "crippled" child, "dependent" on books (usually textbooks), who has lost the spirits of "thought" and "inquiry."

Democracy and Education, Dewey's second major work on education, was published almost sixteen years after *The School and Society*, in 1916, and by then the progressive movement in education had peaked. While much of the book reviews and develops ideas that Dewey had already articulated, the concept of "experience" plays a much more pivotal role, as is the case in Dewey's philosophy in general. Dewey describes how he intends to use the term and its relation to education early on.

> We employ the word "experience" in the same pregnant sense. And to it, as well as to life in the bare physiological sense, the principle of continuity through renewal applies. With the renewal of physical existence goes, in the case of human beings, the re-creation of beliefs, ideals, hopes, happiness, misery, and practices. The continuity of any experience, through renewing of the social group, is a literal fact. Education, in its broadest sense, is the means of this social continuity of life (2).

Education refers to the continuity of "renewal" and experience. It is what allows a social group to shape the future experiences, via practice, beliefs, etc., of its members. In evolutionary terms, it is how a group regenerates itself and ensures its survival. Dewey characterizes this kind of education as a "necessity of life." Just as social environments in general "educate" by encouraging certain dispositions and activities while discouraging others, and not always consciously or directly, so too formal education must shape the "experiences" of its charges, a point made by William James in his *Talk to Teachers* in 1892. Not surprisingly, then, this renewal is subject to the politics of the society doing the renewing. This is especially the case in the US, which had undergone great changes at the end of the nineteenth and the beginning of the twentieth centuries which made a properly thought-through, "directed" educational process key. It should, however, not do so through "control"-where an outside force is brought to bear on a child, but through "guidance"-where the natural capacities of individuals are assisted through cooperation. The idea is not to subordinate an individual's natural impulses to a socially acceptable end (ala Freud's *Civilization and its Discontents*) as individuals are sociable in the first place and thus are, "chiefly interested upon the whole, in entering into the activities of others and taking part in conjoint and cooperative doings. Otherwise, no such thing as community would be possible" (24).

Education should not be "habituation" or "adjustment" wherein individuals are passively molded into the terms set by their social environments. One must understand that the end result of good education can frequently be changes in the social environment itself. In fact, in his later works, especially his work in the journal *The Social Frontier*, Dewey stressed this point repeatedly. While individuals tend to have natural stimuli and responses, education directs them to particular objects. This involves both focusing and ordering the response/behavior. Education can also direct these kinds of activities by shaping the particular meanings they have for individuals-as minds are, in the vocabularies of pragmatism and evolutionism "organized habits of intelligent response" (32) and have "the power of understand[ing] things in terms of the use made of them" (33)-thus helping individuals "pass judgment" on a particular idea or activity's net worth. Education always has an aim, which is then translated into a pedagogical practice, practices which must be able to capture the interest of the student so that they are integrated into a child's experience. For Dewey, knowledge should never be taught as static or a-temporal, but always with regard to the human needs that it was initially developed to meet. Unfortunately, modern society tends to obscure the sources of this kind of knowledge-work, the kind of knowledge-work necessary for life, especially through technological development.

In a key chapter of the book, "Experience and Thinking," Dewey explains the relationship between these pivotal concepts in his thought. To put it very simply, thinking happens in experience. In other words, mind does not acquire knowledge as a passive spectator, nor does mind acquire knowledge by giving an object "attention." Instead, knowledge is acquired through active participation in the world. This does not mean reflection is unnecessary as the best kinds of experiences contain moments of reflection. In fact, thinking is "an explicit rendering of the intelligent element in our experience" which "makes it possible to act with an end in view" (146) as it is only through thinking that we come to understand the relationship between things and thus the consequences of our activity. Reflection is the acknowledgement of "responsibility for the future consequences which flow from the present activity" (146). Thoughts are acts to be performed. Dewey states this even more directly in *How We Think* (1933), where he characterizes thought as making possible action with a conscious aim and converting "action that is merely appetitive blind, and impulsive into intelligent action" (17). This is exactly the opposite of what Dewey refers to as "mechanical" thought, a consequence of external tutelage and the loss of freedom. Furthermore, reflection occurs in concrete situations which have not yet played themselves out; in other terms, thinking occurs when things are problematic or doubtful. It is a kind of quest for a solution to a specific problem or issue. From here it follows, for Dewey, that a good education must design problems for students so that, through their engagement with the problem, learning and thinking occur.

Science education is a particularly good metaphor for this type of education as well as a means for accomplishing this kind of education as it consists of "the special appliances and methods which the race has slowly worked out in order to conduct reflection under conditions whereby its procedures and results are tested" (Dewey, 1916, p. 189). He explains,

> Without initiation into the scientific spirit one is not in possession of the best tools which humanity has so far devised for effectively directed reflection. One in that case not merely conducts inquiry and learning without the use of the best instruments, but fails to understand the full meaning of knowledge. For he does not become acquainted with the traits that mark off opinion and assent from authorized conviction (189).

Science is also important in that it is "the chief means of perfecting control of means of action… witnessed by the great crop of inventions which followed intellectual command of the secrets of nature" (224)-a slip of the pen, perhaps, as a self-identified "instrumentalist" like Dewey does not generally believe science yields the "secrets of nature." The idea that science is a unique kind of experience which yields valuable knowledge and frees experience from all that is strictly personal and immediate, a key ingredient for social progress, is developed into an all out theory of scientific thinking by Dewey in his *Quest for Certainty* (1929).

The goal of education is to provide students in the US with a sense of freedom, a variant of the kind of freedom they already have in a liberal democratic society, at least when it operates without corruption in its ideal form. Thus, in a sense, to experience this freedom, one had to submit to the liberal-democratic order. After all, in the case of good education,

> we are not obliged to insist upon the need of obvious, or external, freedom. It is enough to identify the freedom which is involved in teaching and studying with the thinking by which what a person already knows and believes is enlarged and refined. If attention is centered upon the conditions which have to be met in order to secure a situation favorable to effective thinking, freedom will take care of itself" (Dewey, 1916, p. 304).

Dewey makes a similar point in *Experience and Education*, where freedom is the "power to frame purposes, to judge wisely, to evaluate desires by the consequences which will result from acting upon them; power to select and order means to carry chosen ends into operation" (1938, p. 64). For Dewey, we live in a democratic society where this kind of intellectual freedom is valued and not one where intellectual subjection "is needed for fitting the masses into a society where the many are not expected to have aims or ideas of their own, but to take orders from the few set in authority. It is not adapted to a society which intends to be democratic" (305).

Here one finds the essence of the relation between thought and democracy: we can survive as long as we have "intellectual" freedom because democratic societies insure that this type of freedom becomes freedom in every sense including the freedom of people to determine the basic conditions of their own lives. In an address to the NEA, Dewey goes further, democracies are "the best means so far found, for realizing ends that lie in the wide domain of human relationships and the development of human personality... [in that it requires] ...the necessity for the participation of every mature human being in formation of the values that regulate the living of men together" (1937, p.400). If, by chance, one does not accept this premise about the nature of contemporary democratic societies, or if one doubt's that such a kind of democracy is possible under US capitalism, premises Dewey never fundamentally questions (with the exception of a few brief years around the Great Depression), then one is left without much freedom. Dewey was faced with this issue in the pages of the radical education journal *The Social Frontier* in the 1930s, where the argument was often made that education must begin from the perspective of class struggle. To this Dewey often responded that this position confused him, as this kind of a priori would make substantive education impossible. Of course, for Dewey, that was never the case about his own a priori's about education from the perspective of US liberal-democratic society!

Finally, I want to return to a point I mentioned earlier-just what is it that is so disturbing about "mechanical" thought for Dewey? It should come as no surprise that in Dewey the opposition between mechanical and intelligent thought mirrors the opposition between authoritarian and democratic societies. Because, for Dewey, democratic societies are founded on the faith that all human are equally capable of intelligent thought, they reject the idea that someone must do people's thinking for them, precisely the kind of thinking evidenced in mechanical thought. Thus, mechanical thought leads to authoritarianism and the destruction of democratic institutions. This is why Dewey reviles it so. At least, this is the explanation Dewey gives over and over again. But that is not the entire picture. We can see some of this play out in Dewey's politics. On one hand, he was very supportive of teachers efforts to unionize in the 1910s and 1920s, supported the Soviet educational system after he visited it in person and offered Trotsky a fair hearing (although this upset many communists); on the other hand, he supported US entry into the First World War, resigned from the ACLU and the Teacher's Union "Local No. 5" in the 1930s when he suspected that communists had "infiltrated" the organization and joined the "Committee for Cultural Freedom" along with Sidney Hook in 1939 which was notoriously anti-communist, even going so far as to publish lists of organizations under communist "control."

As I suggested previously, Dewey's entire system is based on accepting the relationship between US democracy, intelligence, science, and freedom. Dewey's ultimate naiveté was to conflate the American republic with the ideals of the Platonic one. His quasi-religious faith in democracy as the *eschaton* of history and progress complemented his relativism and made his work extremely attractive to his generation of scholars (Ross, 1991). Naturally, the communists threatened these relations as they pointed to a fundamental problem that Dewey refused to truly acknowledge: was it really possible for a society that valorized the unfettered accumulation of wealth, for a society with such extreme inequities in the distribution of wealth, to be democratic? Can capitalism and democracy ever be reconciled? Furthermore, the communists suggested the possibility, following Marx, that the appearance of freedom in liberal-democratic society was not exactly what it appeared to be. The rhetoric of democracy disguised a more fundamental lack of freedom, or at best, a very constrained freedom. Finally, critics of capitalism suggested these societies maintain themselves through intellectual hegemonies which are frequently taken-for-granted. Ultimately, Dewey's uncritical acceptance of liberal democratic societies made these kinds of questions unasked. It made it "obvious" that freedom and democracy are the same thing and that one had to focus the fight for freedom in thought. Once people possessed this kind of freedom they willingly subjected themselves to the norms and laws of democratic societies. These ideas had a tremendous effect on the shaping of progressive education, making it fundamentally conservative in its political program and, in the end, explaining why it never succeeded in transforming the educational system.

Chapter Three: Laboratory as Fetish

The school science laboratory was a fetish in the sense that Freud uses the term in his *Three Essays on Sexuality*--it "stood in" for all that was held to be dear about science, democracy and America in general. As I hope to demonstrate, in the laboratory, just as in the larger society, one was free to do "good" science precisely because one subjected oneself to the authority of a good instructor and a good set of methods. Furthermore, good science in schools came to signify good democracy in the rest of American society. Real democracy-soon to be contrasted with any socialist or anarchist variant-involved the curtailing of freedom in order to thrive. Thus, while some might bemoan the nature of US democracy, decrying it for having stringent limits with respect to how much people could participate, this was precisely its strength.

By the progressive era (roughly 1900-1919),[1] the days when American politicians could be explicit about their fear of mob rule were long gone. The days when equality was explained by selective pressures were also coming to an end. People became more comfortable with an interventionist state. The old Protestant gentry no longer exclusively dominated American life and other groups became involved in creating social change reflecting somewhat of a broadening of American democracy. This period was quite violent with respect to US labor history and was also a period when socialism in the US had it most success.

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[1] While there is no clear consensus on when the progressive era ended, it seems that the beginning of the US's entry into the war as well as intervention into the October revolution was transformational and disillusioning to many progressives as it highlighted the imperialist and commercial motives behind US foreign policy.

A new sense of the term "democracy," along with a related term, "freedom," was articulated during these years. The idea was that real freedom had limits. This functioned to curb too much government intervention or too radical social transformation by reminding people that endurable freedom required a relatively-intractable law and stable society. To be free, this logic explained, people must be willing to subject themselves to this law, even if they don't always agree with it. In science, the idea of freedom through submission was mirrored through one's subjugation to a scientific method. What made this subjugation unique was that is was freely taken up and not forced from above or "authoritarian." Though usually not explicitly, science education could teach children these vital lessons about real democracy.

Central to the political organization of modern, liberal-democratic societies sits a contradiction between freedom and authority or dogma-both in thought and in action--which gets fully developed in the US during the early years of the twentieth century. Borrowing ideas developed by the English philosophers of the seventeenth century (Hobbes, Locke), Rousseau and later Kant, though best expressed by the great American philosopher of the period, John Dewey, US society and the individuals who lived in it were simultaneously free and subject to the law. More exactly, they were free precisely because they subjected themselves to the law. In science education one finds a similar dynamic in rhetoric around the laboratory, a space which comes to signify the soul of a good science education in this period. In it, school science could reach the freedoms promised by US society. But, this involved accepting certain limits. The freedom of the US and the freedom in its laboratories were to be contrasted with the authoritarianism of the Old World, and after 1917, with the implicit un-freedoms of the Soviet Union. The construction of this relationship offered the United States an unparalleled opportunity, nearly a century of vilified authoritarian societies which, it was argued, demonstrated the superiority of the American system and the potency as well as equity of market democracies. Following Dewey, laboratories were to be spaces of "free-inquiry" and not spaces for "rote learning" or "bookwork." The force of technology in US societies would betray Dewey's vision-"facts" would simply be replaced by routinized processes as the contemporaneous logic of technology required that facts and processes be related but distinct. For Dewey, of course, in experience one could not make such distinctions. As much as reformers tried, the laboratories became sites for "rote learning" as well as a site for the generation of a foundational tenet of US education-the division between facts and process-a distinction that haunts US education to this day, a division which continues to alienate children from knowledge.

Many of these reforms were done in the name of science. As the old-Protestant gentry began to feel less and less secure about their place in American society and felt responsible to protect its old Republican ideals, they refashioned themselves from a quasi-aristocracy into a class of "experts" (Ross, 1991). While they could no longer use their class position as a reason why their programmes of reform should be followed, many now claimed expertise of one kind or another in the growing fields of social science. As public education became a focus for reformers, educational reform was inundated by experts. Here, I will identify a key site for the legitimation of education through science-the scientifization of education. Educational practice as well as the school system itself would rationalize and legitimate themselves by becoming more scientific. In the modern world, as Weber argued, it would also mean becoming more bureaucratic (Weber, 1968). Because public education would continue to reproduce the social relations that already existed in US society, particularly with respect to class, ethnicity and race, with a few modest exceptions, this new scientificized education (e.g. in testing, educational research, teacher training) would communicate that the lack of success on the part of certain minorities was not due to the system but to the failure of those individuals or their communities to learn properly.

1. Progressive Education/Science

The progressive years were a time when the individualisms of the Gilded Age were no longer politically popular and the culture-at-large shifted its focus to reform. One finds a broad impulse toward criticism and social reform in the US that was widespread after 1900 and lasted, in different forms, until the First World War. Reformers regarded America as having been corrupted by corporations and the urban political machine and sought to return the country to the kind of economic individualism and political democracy which had existed earlier in history. The kind, it was assumed, that would bring back a lost sense of collective morality and civic purity (Hofstadter, 1955). Within limits, progressives sought to broaden American democracy. They sought to create a sense of collective responsibility in the social order wherein more successful classes shared with others the benefits they acquired from an expanding economy, all within an ideal set by the terms of the industrial and corporate sectors (Weinstein, 1968). While the early roots of the progressive movement lay in the farmers populist movements of the late nineteenth century, by and large, progressivism was fundamentally a middle-class movement, the response of an educated, white, Protestant, gentry to some of the dramatic changes brought about by the industrialization, immigration and urbanization of the United States (Hofstadter, 1955). At heart, progressivism was a relatively conservative movement, quite literally, seeking to fix the status quo so that capitalism remained rational and stable, a response to pressures of big business and the threat of socialism.[2]

The progressive movement regarded the US public school system as a key site for its reforms. One event which set off the progressive movement in education was the publication of a series of articles in *Forum* by Joseph Mayer Rice on the state of American public education. Rice's work came at the start of the "muckraking" tradition in journalism and pointed out that public indifference, political corruption and general incompetence were coming together to ruin American public schools. Schools were filled with children droning mindlessly, repeating meaningless verbiage. Rice argued that public schools would have to be divorced from politics and reorganized by the public in their communities. While many criticized Rice and dismissed him as a "high-minded intellectual" as well as pointed to his lack of experience in the field of education, others recognized that Rice had identified some fundamental problems in public schooling. Rice was the first to take the many streams of educational criticism that had existed in nineteenth century America and unite them into a call for national reform. Progressive's in education borrowed Dewey's idea of a "child-centered" education, but in practice, were usually not able to create the kind of learning communities that Dewey envisioned. The progressive movement in education culminated with the establishment of The

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[2] The threats to the social order were quite apparent to all. For instance, violent labor strikes rocked the country in 1877, 1886, 1892, 1898, 1912, and 1919 and the socialist Eugene Debbs received over 6% of the vote in the presidential election of 1912.

Association for the Advancement of Progressive Education in 1919 (Cremin, 1961). By 1928, progressive education had become such a mainstay that Margaret Naumburg could write in *The Nation*, "anything less than 'progressive education' is now quite out of date in America" (cited in Cremin, 1961, p.249). Like Rice, influential authors like Jacob Riis [*The Battle with the Slum*] and John Spargo [*The Bitter Cry of the Children*] came to regard education as key to supporting the kind of reformist agenda adopted by progressive political thinkers. For many, the transformation of schools would be a key part of the broader reform of American society.

As the twentieth century progressed, progressivism adopted a far more explicit scientistic stance. As American capitalists, reformers and modernizers realized the potential economic and social benefits of "scientific" knowledge, they supported the professionalization of science and the expansion of higher education (Ross, 1991). Science was regarded as vital to bringing about the reforms advanced by the progressives as it was seen as a way to legitimate progressive ideas when they were attacked. Progressives regarded the scientific expert as a key figure in the institutionalization of their reforms. Take the case of the science of education developed by Edward Thorndike in this period. His quantification of teaching practice and knowledge, which eventually led to a full-scale testing movement, promised to identify successful schools and thriving teachers and children. Thorndike was famous for proclaiming that "all that is… could be measured." Educators, eager for more respect for their undervalued work and frustrated by new urban schools filled with the new classes of "low achieving" immigrants and poor, seized on the possibility of professionalizing their work through science

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(Langemann, 2000). The quantification of the work of educationalists and the opening of professional schools like Teacher's College at Columbia University, led to an increased perception of their professional status. Furthermore, it resulted in the development of classes of mostly male educational experts to "supervise" mostly female teachers.

Early twentieth century educational science went even further. Instead of recognizing that economic and political inequality was endemic to the American political set-up, especially in the case of the non-Anglo immigrants and blacks, a vast system of "intelligence" and "personality" testing was set up to explain why certain groups seemed to fail in the land of opportunity. This system was aided by developments in the use of statistics and the eugenicist views of many involved in these developments (Kevles, 1985). The idea of racial difference had been used to justify European colonialism for centuries, but the testing movement gave it a whole new scientific veneer. Although many of the original authors of the tests later recanted them, often recognizing that they measured familiarity with American customs and language rather than any innate mental capacity, the testing movement in education persisted (Gould, 1981), likely a function of its incredible financial and political successes. Also, eugenics was not necessarily a movement limited to those on the political "right." Some progressives believed life for immigrants, the poor and people of color could be made better through improved breeding habits. They bitterly opposed the policies of non-intervention and were disturbed that some progressives wanted to leave evolutionary development up to the brutal laws of nature (Bannister, 1979). Many philanthropists funded studies in eugenics to help make the public more "eugenic-minded" and were, in large part, responsible for the science of genetics (Kevles, 1985). The movement was aided by a shift in evolutionary thought wherein the unit of selection became the race or "population" rather than the individual (Hofstadter, 1959). Thus, Northern Europeans, now reconfigured as a unique race, were regarded as fitter than those from Southern Europe, Asia or Africa. A general respect for anything designated as scientific in US culture helped the more conservative interests in these movements pass restrictive legislation like the immigration restriction laws passed in the 1920s, arguing that only such restrictions would protect the purity of white American culture.

Another legacy of the Progressive era, as eloquently detailed by Raymond Callahan (1962), was the rise of the administrative bureaucracy and the efficiency expert. As Callahan tells it, the rise of big business to prominence in US society as well as the force of the reform movement made school administrators particularly vulnerable and easily manipulated by the ideas and practices of business and industry. When schools were compared to business enterprises, as they frequently were in this period, they often came up short: they were inefficient, wasteful of resources, ineffectual and poorly managed, or so the criticisms would go. Leonard Ayres' *Laggards in Our Schools* developed an "index of efficiency" which measured the efficiency (or more precisely, failure of efficiency) of schools (Callahan, 1962). Texts like William C. Bagley's *Classroom Management* (1907) and J. M. Rice's *Scientific Management in Education* (1913) suggested that classrooms need be managed like businesses and that the standardization of education could make it more efficient. The president of the NEA captured this spirit well in 1900. "The real educational leaders of the age whose influence will be permanent are those who have business capacity to appreciate and comprehend the business problems which are always part of the educational problem" (cited in Callahan, 1962, p. 8). School leaders were pressured to introduce "vocational" education so that graduates could advance American industry and technology. Not everyone accepted this new direction for education, however, as William Maxwell, superintendent of the New York City public schools put it in 1913

> Nothing had been so arrogant as the agitation with which the educational world is now seething for the introduction of industrial or trade teaching in the public schools. That agitation, as every one knows, originated with the manufacturers. They had practically abandoned the apprenticeship system of training workmen. *No longer training their own mechanics, they have found it difficult to obtain a sufficient supply of skillful artisans... Out of this dilemma the exit was obvious-persuade the State to assume the burden...* (ibid, p.13).

Added to the mix was Fredrick Taylor's extremely influential "scientific management" which was soon applied to teaching and running schools. To help schools in this time of crisis, the efficiency expert was born. Individuals like Frank Spaulding, superintendent of the schools in Newton, MA and Franklin Bobbitt of the University of Chicago developed measurements and remedies for schools-like making curricula more "relevant," creating larger classes, or establishing standardized criteria for qualifying teachers. These would make schools more efficient. One of the most influential educators of this period, Ellwood P. Cubberly, in his *Public School Administration* (1929), lauded the new scientific movement in education in that it helped the public understand how schools are becoming more efficient and how each pupil is being properly examined and classified. Outside efficiency experts were often contracted to evaluate a particular school. All too often, detailed records and reports were regarded as signs of efficiency and school administrators were inundated with paperwork. School administrators were no longer expected to be educational leaders but instead accountants and managers. Teacher training colleges developed courses to train these new bureaucrats. In 1911/1912 Teachers College offered only two courses on school management, by 1924/25 they offered twenty-nine (Callahan, 1962). The tragedy of this, according to Callahan, was that so much time was wasted on reforms which had very little to do with education and only ended up creating the bloated educational bureaucracy one finds in most large school systems today.

2. Science by Committee

By the last decade of the nineteenth century, many were calling for a standard framework by which curricular matters could be decided given the chaotic and heterogeneous state of US education. Science education became a key part of this frame and the war against book-work and text-book knowledge, key illustrations of "authoritarian" thought, would be waged in these curricula reforms. US Commissioner of Education, and former president of the NEA, William T. Harris, was especially concerned by the revelations of the muckrakers that teachers were simply forcing students to memorize and recite pages from textbooks. Even William Graham Sumner regarded US education as too conservative, unable to progress or handle innovation (Sizer, 1964). Because, as Sizer points out, most of the focus of the NEA and other organizations was on the poor curriculum and quality of teachers, they tended to ignore corruption and other systemic problems faced by the school system. In 1892, a Committee of Ten was established by the National Education Association's National Council of Education with the express purpose of making college entrance requirements more uniform. The NEA, founded in

1858, had been pushing for nationally recognized standards in education. The idea was that this change would make the work of secondary schools easier by identifying which specific subjects they had to teach if they wanted to prepare their students for college. Although its original mandate was to make college entrance requirements uniform, the committee would ultimately provide a blueprint for the development of curriculum on the secondary school level.

The Committee of Ten was headed by Charles Eliot, the president of Harvard University and a key figure in bringing science to Harvard. Although Eliot was frequently charged with exploiting secondary education for the benefit of the colleges, he regarded the introduction of the college curriculum into high school as a step toward achieving democracy in education whereby children from all classes could be equally capable, regardless of educational opportunity, very much in the tradition of Horace Mann and Thomas Jefferson (Krug, 1961). In a certain sense, Eliot's recommendations, which would soon go unheeded, are more in the tradition of what I have termed critical education than schooling.

In general, the recommendations of the committee centered on this democratic principle and insisted that all students have access to the same quality of education, regardless of their occupational paths. Yet, at the same time, they recognized that secondary education need be valuable for those students who do not plan on entering college and therefore must prepare them "for the duties of life." The report reflected a compromise between the older understanding of education as providing mental discipline and the more recent focus given the changing social arrangements of US society that education prove itself to be practical (Sizer, 1964).

The work was organized by conferences devoted to subject matter, three of which focused on science-one on natural history, which included physiology, zoology and botany, a second on physics, chemistry and astronomy, and the third on geography, geology and meteorology. Each conference was instructed to explicitly lay out how a subject should be introduced, which topics need be covered, how much time should be devoted to the subject, how might a college test for knowledge in this area, and should the curriculum differ depending on whether a student planned to go to college? By the time the committee released its report in December of 1893, they had agreed that science should compose 25% of the curriculum, reflecting a substantial increase over what had been the previous norm and that, in general, teachers needed to be better prepared to teach children how to observe simple, natural phenomena (as well as paid better, as quality labor in this area was, according to the report, indispensable). With respect to physics, chemistry and astronomy, the committee agreed that these sciences should be tested by a college entrance exam which included an experimental component. They argued that the study of these fields must begin early in life and be taught as much as possible by means of experiments carried out by students in the laboratory. At least half of instruction in these sciences in high school was to be laboratory work where activities were to be recorded carefully in a laboratory notebook and the work was to be carried out under the guidance of an experienced teacher who helped students interpret their results.

This was set to oppose the kind of "loose work" that was already prevalent in high school labs as well as the dependence on textbooks.

In the physics lab, students would be required to measure and calculate the properties of objects and phenomena as well as attempt to verify physical laws. In the chemistry lab, students would focus on the preparation of simple compounds and an examination of their properties (NEA, 1893). The other two conferences, particularly the one on natural history, also focused on the importance of "observation" in the study of science, though it suggested that these observations be related to the practical day-to-day life of children including a focus on hygiene, nutrition, and the direct study of nature. In general the report argued that science was to be taught in laboratories, focus on "observation" and "direct contact," be guided by an "experienced instructor," while it rejected the dogma of textbooks and the memorization of facts. A later report on college entrance requirements explained this further.

> Probably the most general method of teaching zoology in secondary schools at present is the text-book method. A large amount of information about animals is acquired thereby in a limited time, and the minimum of attainment and preparation is demanded of the teacher. Your subcommittee on Zoology is unanimously opposed to this method for not only is undue emphasis laid on the larger forms of animal life, but also no course has any right to be regarded as a course in science unless it include laboratory work. (NEA, 1899 cited in DeBoer, 1991, p. 52-3).

> When [chemical] symbols and formulae are first introduced, special care must be taken to show how they are derived from quantitative measurements. The pupils own observations and other examples must be used to show how the formulae, and finally the equations, are reached as expressions of quantitative relations. The whole process of determining the proportions by weight and constructing the formulae and equations must be done or described in connection with every chemical change, until the pupil is thoroughly familiar with the formulae and the exact significance of the equation is perfectly clear. Formulae must on no account be used before this can be done, as otherwise they will inevitably appear to be the course of information rather than the receptacle for it (ibid, 53).

Let's look at these two statements a bit more carefully and see what they reveal about the nature of the science education of this period. The vilification of the textbook makes sense-it represents authority and dogma of the old education where individuals did things because they were told too. This was not science, certainly not the science of a liberal democratic society. Here, just as individuals were free, so too the science they practiced was free. But not quite free, as the report makes clear. While students should not use formulae until they are "thoroughly familiar" with them as they will then appear to be "the course of information," they will use the formulas once they "understand" them and their "exact significance" is clear. To put it another way, due to their "understanding" they will willingly take up the formulas and utilize them. Just as the American will willingly accept the law when he or she understands its just and democratic character, so too will that individual take up the formula when it is properly "understood." The science teacher's job is to precipitate this understanding.

One of most virulent attacks on the Committee of Ten came from the American Philological Association who objected that the committee recommended only two years of Greek in the classical program. They established their own "Committee of Twelve" which fought for a restoration of Greek and Latin into the curriculum (Krug, 1961). Another major critic of the report was psychologist G. Stanley Hall who objected to the idea that school subjects should be taught identically, regardless of a pupil's career goals. He insisted that "fit-for-college" was not the same as "fit-for-life." Hall also objected to the report's refusal to recognize and account for, in terms of the curriculum, innate differences in intelligence between different children. Eliot, who generally did not respond to criticism of the committee's work, responded to Hall's attack arguing that this type of curricular "equality" was necessary to maintain a sustainable democratic society.[3]

The report was very influential in communicating the value of science to high school study, the importance of quantitative (as opposed to simply inductive) laboratory work and the necessity of training qualified teachers, though it did not have marked effected on actual curriculum. (Dexter, 1906). As a result, laboratory work became more strenuous, time consuming, and in the words of one high school inspector, "irksome" (Goddard, 1916). There was much concern after a 1901 report by the US Commissioner of Education which showed enrollment in chemistry and physics declining and the editors of *Popular Science Monthly* in 1904 mourned that science as taught in schools is no longer "attractive" to most students.

The next few decades witnessed several crises around student's lack of "interest" science. By the turn of the century, focus began to shift to making laboratory work more "interesting" (Henderson, 1908). Such was the early effect of the progressive movement on science education. Soon it would also have to become more "practical" and as more children of the immigrant poor entered the schools "vocational." If children became "interested" and were able to utilize science, thus taking it up on their own, surely they were free. In 1918, the NEA organized the Commission on the Reorganization of

[3] Just to get a sense of how much education would change over the next thirty years, in his *Child-Centered School*, Harold Rugg (1928) dismisses the work of the committee as part of a "reactionary right" and part of an "era of uniformity" (p 24-5). By this time, the committee had come to symbolize the dominance of the college curriculum and conservatism.

Secondary Education, which released several reports including one on science education in 1920. Previous to this, the NEA had released a preliminary report which claimed,

> Certain defects of science courses in content and in methods are becoming increasingly apparent. In some respects, science teaching is not as closely related to the environment and experience of the pupil today as it was a quarter century ago. With the elaboration of apparatus and the increased attention to quantitative methods, there has come an aloofness from the experience of everyday life, so that the pupil may secure a high standing in physics, chemistry or biology without necessarily gaining an understanding of their applications. Moreover, teachers in science in some instances overemphasize the importance of formal and fixed procedures and, as a result, are not alert to utilize new opportunities (NEA, 1918, cited in DeBoer, 1991).

This time, the problem which needed to be addressed was less the mismatch between secondary schools and the college curricula but the lack of social relevance in the curriculum. Much of the progressive focus on utility was related to the explosive growth of children entering school, many of them non-English speaking, poor immigrants, and the anxiety they evoked around tainting US culture with their backward ways. Education was, according to Clarence Kingsley, chair of the commission, to develop individuals so that they can be effective at work as well as participate in US democratic institutions. Progressive education would focus on inculcating these new Americans with the norms and value of the "natives." So, for instance, History was gradually replaced by Social Studies in this period, a field which focused directly on rationalizing US political institutions and social life. The history of the United States was increasingly told, unabashedly, as the flowering of democracy. The inequality and poverty experienced by these immigrants was a result of their inability to properly Americanize and did not reflect any failure on the part of US society.

Many of the committee's recommendations were "vocational" in the sense that they be organized around particular kinds of employment including agriculture, business, clerical, industrial, household, etc. (DeBoer, 1991). In fact, by 1917, vocational education received funding directly from the federal government. The science committee justified science in schools on the grounds that it,

a. was necessary for health and public hygiene
b. can instruct individuals on the use of technology
c. can be valuable for different vocations
d. give people a better sense of the contributions of scientists
e. enhance leisure through technology
f. contribute to an ethical character by establishing an… conception of truth

(NEA, 1920, cited in DeBoer, 1991, p.70).

These priorities reflect a dramatic shift from the priorities of the original advocates of science education like Huxley and Youmanns who, even though they argued for the importance of science for getting on in the modern world, also believed that science inculcated a particular appreciation for nature and ways of thinking. Not surprisingly, it was the immigrant and non-white poor who would get this much needed training in "public hygiene" and "ethics." By 1920, the focus on the purpose of science education had shifted dramatically from developing the intellect and skills of observation to making individuals contributing members of society. Dewey's vision of a "child-centered" science was lost.

With respect to the laboratory, the report reaffirmed that it was crucial for school science. As in previous committees, it bemoaned the amount of useless activities which took place there like "elaborate drawings to keep children occupied until the end of the period" or "too many experiments [which] involve repetition of work described in the text" (NEA

1920, cited in DeBoer, 1991, p. 77). It urged that laboratories be used to develop ideas and help students pose particular problems which they can then attempt to answer through their laboratory work. Further, in physics labs, the authors of the report bemoaned that too much time was spent verifying laws and learning to be accurate observers, practices which in fact, the committees of the late nineteenth century had lauded; instead, study should be more focused around a particular problem to be solved through an "investigation" so that the student was "...getting real practice in the use of the scientific method" (NEA 1920, cited in DeBoer, 1991, p.78). Finally, these investigations should be designed so that they arouse interest in students so that the work has both personal and social relevance, and thus increasing student motivation. A later NEA report, devoted exclusively to science, explicitly laid out what was to be accomplished in the laboratory.

1. The development of simple laboratory techniques, such as weighing, glass bending, microscopic manipulation, etc.
2. Providing and establishing for the pupil himself principles which have long since been well established and generally accepted.
3. Using the laboratory as an instrument for object, or 'thing,' teaching, according to the historical concepts of Pestalozzi, Comenius, and Basedow.
4. Using the laboratory for the purpose of developing better understanding and interpretations of the principles of science, as a means of better illustration.
5. To produce training in scientific method.
6. As a means of possible training in the experimental solution of the pupil's own problems.
7. The use of the laboratory as a workshop for the study of science problems which arise in the science class or in the life of the pupils (NSSE, 1932, p. 270).

Notice the case of the second and fourth directive-the laboratory in which the student was supposed to actively construct knowledge would, remarkably, identify principles "which have long been well established" and be used as "a means of illustration." At the same time, the laboratory would help students develop "experimental solutions" to their own problems. Are these "solutions" also long established? It appears that a lot is being laid at the doorstep of the laboratory. On one hand, thought will be creative and on the other, simply a repetition of thoughts gone by. This reflects, I argue, the laboratory's role as "stand-in" for the space where the practical expressions of freedom and democracy, in the particular form they take in the United States, are played out. After all, the tension between autonomy and subservience to the law and market lies at the heart of the notion of democracy in the US, with autonomy almost always becoming more appearance than reality.

And yet, not everyone agreed with this new conception of a "practical" science education. Critics like Robert Bradbury, head of the Department of Science in the Southern High School in Philadelphia, contended that this focus on bringing the science closer to the lives of pupils had the effect leaving them ignorant of basic chemistry and more knowledgeable about specific technologies then about the science of chemistry (DeBoer, 1991). No doubt, this was the case. Science education helped teach the poor and immigrants that their salvation lay in technology, the practical expression of science, no matter that many could not miss the ways in which some of the new technologies drove wages down and often made working conditions unbearable. Implied in this lesson was that the needs of the market drove the political. Although many would eventually criticize progressive education for its focus on practicality, by 1915, a survey found that over 50% of teachers listed the practical aim as one of the most important in teaching science (DeBoer, 1991). The practical focus in education would further solidify some of the problems I identified earlier. By creating an education for "everybody," US public schools could maintain that their curriculum was democratic. By focusing on "inquiry," it could also communicate that real freedom involved subjection to law, including the laws of method and the market.

3. Laboratories in Action

By the early twentieth century, many students in elementary and secondary schools were spending significantly more time in science classes than they had in previous decades.[4] In chemistry, one of the most popular textbooks of the nineteenth century, *Fourteen Weeks in Chemistry* by J.D. Steele devoted only about 10% or so to directions for laboratory work contained in an appendix. In physics, the popular *First Lines of Natural Philosophy*, published in 1846, did not deal much with laboratory activity at all. In high schools, individual laboratory work began in earnest in the 1870s in chemistry and a bit later in physics (Efron, 1937). Generally, from the late nineteenth to early twentieth century textbooks became more inductive and more concerned with the replication of actual science. This changed after 1905 when texts attempted to make science more practical, useful for daily life, and related to the interests of the students. (Rusk, 1923). In addition to the report of the committee of ten in 1893, the publication of the Harvard Descriptive list of physics laboratory experiments, published in 1886, influenced the proliferation of laboratories in schools. Other influential documents, both of which I have previously discussed, included the report of the Committee on science of the Commission on the

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[4] One study of grade allotments by subject found that, in elementary school, the total time devoted to science increased from less than 1% in 1866 (before this science was not even a category) to about 2.5% in 1904 to about 3.5% in 1914 (Mann, 1928). The number of students enrolled in public high school chemistry peaked in 1890 (10.10%—down to 7.07% in 1928) and in physics in 1895 (22.77%—down to 6.85% in 1928) [the numbers were slowly increasing again by 1932].

Reorganization of Secondary Education in 1920 and the Thirty-First Yearbook of the National Society for the Study of Education, both offering detailed ideas of how laboratories should be used to teach science (NSSE, 1932).

The first high school laboratories opened in high schools in Philadelphia and Chicago in the 1850s but as recent as 1911, many were described as "meagerly equipped." In 1900, the University of the State of New York recommended that laboratory work comprise 108 hours total and in 1905, the New York State syllabus required at least 30 double periods of laboratory exercises. However, in spite of these requirements, in the first decades of the twentieth century in New York, only 30.4% of public schools conducted laboratory work in double periods (26.3% nationally), the others used single 45 minute periods (the former better for in-depth lab work). In addition, 54.4% of schools spent less than 100 hours on laboratory work (46.1% nationally). Essays like "A plea for experimental work by the students in teaching a first course in physics" (Moncrief, 1903) reflected the extent to which science educators were concerned about the lack of laboratory activity. To their delight, by the 1920s, the figures increased dramatically with 86.8% of schools across the country using double periods for laboratory work and 76.6% giving it more than 100 hours.

Over the course of the progressive period, many science textbooks began to lay out what school science should look like and what kinds of scientific work should be done in laboratories. Take F. W. Westway's *Science Teaching*, published in 1929, which offers extensive discussions of what syllabi and laboratories should look like. With respect to the laboratory, of which "no part of a science teacher's work is more difficult than the preparation of suitable "directions" or "instructions" for pupil's practical work in the laboratory" (ibid, 47), it is key that the teacher provide the student with a clear succession of steps to be followed. The laboratory offers the opportunity for the "heuristic" method where students "discover" things rather than be told them. He cites H. Armstrong, a pioneer in this method of teaching.

> The student is required to solve a number of problems experimentally… each student receives a paper of instructions which are advisedly made as bare as possible so as to lead him to find out for himself or inquire how to set to work; he is particularly directed that, having made an experiment, he is to enter in his note-book an account of what he has done and of the result; and he is then and there to ask himself what bearing the result has upon the particular problem under consideration: having done so, he is to write down his conclusion. He is thus at once led to consider what each experiment teaches: in other words, to reason from observation (22).

Westway recognizes that, at times, the process can work so that students never end up discovering anything for themselves. Is it the pupil who has done the thinking, he asks, or the teacher? "Beware of the pseudo method of discovery… when a boy works an experiment, keep him just enough in the dark as to the probable outcome of the experiment, just enough in the attitude of discoverer, to leave him unprejudiced in his observations" (39). He suggests rather than considering this "discovery" on the part of the student, it should be regarded as communicating the spirit of inquiry in science. Teachers should make sure students follow up on the experiment and piece the details together, never allowing students' to feel like the work is simply an exercise.

Other textbooks offer similar rationale for laboratory work. The influential *Teaching of Chemistry and Physics in the Secondary School* (Smith, 1916) lists several reasons why laboratory work is necessary including (a) teaching knowledge making by observation and induction, (b) teaching knowledge making through the study of natural objects and phenomena, (c) teaching caution and mental rectitude, (d) giving first-hand knowledge, and (e) holding students' interest and attention. Again, the key to accomplishing all this are coherent and well thought through instructions. Otherwise the result can be "a series of isolated, mechanical procedures" (94). Smith lays out, step by step, what a clear set of instructions look like. Students must be told what the object of the experiment is, how the apparatuses to be used work, a detailed description of the materials to be used as well as the handling of the materials and apparatuses. However, one must be careful not to expect that "the pupil should discover the fundamental laws of the subject for himself" (105), for this would be an impossible task, but instead to transmit "an ever-tightening grip on the inner spirit of science" (111).

In a similar vein, in his *The Teaching of Physics*, C. Riborg Mann (1917), Mann explains that many believe that children need to see for themselves the "truth" of science and that the handling of scientific apparatuses in the laboratory would make science more concrete. Mann objects to this, arguing that laboratory experiments must furnish vital information and, citing the previously published Harvard rationale for laboratory work, he explains that experiments are primarily there to teach students to think clearly. Mann complains that most experiments, "are designed simply and solely to furnish a concrete basis for his appreciation of physics. He must go through the motions indicated, not to satisfy his spirit of wonder, but to fulfill to the letter some "requirement" of the school system" (252). On the problem with this, Mann cites Dewey,

> beginning with the concrete signifies that we should at the outset make much of doing; especially, make much in occupations that are not of a routine and mechanical kind and hence require intelligent selection and adaptation of means and materials. We do not 'follow the order to nature' when we multiply mere sensations or accumulate physical objects. If physical things used in teaching number of geography or anything else do not leave the mind with recognition of a meaning beyond themselves, the instruction that uses them is as abstract as that which doles out ready-made definitions and rules; for it distracts attention from ideas to mere physical excitations. The conception that we have only to put before the sense particular objects to impress certain ideas upon the mind amounts to almost superstition...

Both Westway and Mann, influenced by the Deweyian idea that children learn by doing-better yet, doing/thinking-reject the kind of rote technical activity which they contend happens too often in laboratories in contemporary schools. Still, Mann adds that experiments in labs should begin "with the problems of daily life" (262). J. O. Frank's, *The Teaching of High School Chemistry,* first published in 1921, suggests that before 1910, chemistry classes were dominated by a "college" curriculum and were "organized after the German plan of methodological examination and cataloging of all available facts" (8). This quickly led to the kind of repetitious busywork which the author objects to. Today, argues Frank in 1932, the focus is on "scientific investigation of the facts" and not on wasteful activities. Just how would a different laboratory operate? Westway offers the following instructions for a lab activity on AMMONIA

> Introduce about one c.c. of Hg into a wide test-tube; gently warm the metal over a flame, and, directing the mouth of the tube away from the person, drop in a fragment of clean metallic sodium about half the size of a pea. If the Hg... [is] warm enough, the sodium will at once dissolve it with a little explosion-if not, heat gently. Then introduce another piece of sodium of the same size, and after its solution a third. A silvery white amalgam of sodium is thus prepared which retains the metallic luster. Now pour out the warm and still liquid amalgam into about 250 c.c. of a cold saturated solution of sal-ammoniac. The amalgam quickly increases to at least fifteen times its original bulk, and ultimately becomes a large pasty mass, light enough to float on the surface of the liquid. This mass can be removed and washed with water; it presents a brilliant and metallic appearance, but it is very unstable and soon decomposes, evolving ammonia and hydrogen gases, and after some time nothing remains but the original mercury (47-8).

The experiment is used to demonstrate that "there is therefore some experimental evidence as to the existence of a compound radical ammonium, and the close analogies traceable between its saline and other compounds and those of potassium and sodium confirm this view" (48). Westway offers detailed instructions for several other lab activities including "friction between solid bones," "measurement of heat fusion" and "preparation of normal salts." According to Westway, these experiments commonly fail if their main purpose has not been made clear enough to the student or pupils have not been previously prepared enough for the lesson. Still, there doesn't appear to be much for the students to do than follow the teacher's presentation. Another experiment designed to observe heat is laid out in William Tilden's *Hints on the Teaching of Elementary Chemistry*, published in 1896.

> *Observation of the action of heat* supplied by the gradual application of a Bunsen flame to a dry test-tube containing a little of the substance. Any of the following or other substances may be tried: Mecuric oxide, red lead, lead nitrate, potassium chlorate, potassium nitrate, ammonium nitrate, ammonium chloride, mercuric iodine. Gases evolved may be tested for as follows (1) Notice Colour, appearance of fumes, odour. (2) Apply lighted wax taper first at mouth of the tube, then pushed inside. (3) Hold in the gas strips of red and blue litmus paper, moistened with water. (4) Hold within the tube a drop of clear lime water at the end of a narrow glass tube, then gently suck for a moment at the open end of the tube so as to draw up the drop. This series of tests is not intended to enable the pupil to identify the gas, for that is a matter of comparatively small importance at this stage. After observations have been correctly recorded, the teacher may suggest to the pupil other experiments which appear to him desirable, such as the collection of the gas in bulk or further examination of the residue. Some of the substances mentioned in the above list will afford opportunities of testing the genuineness and completeness of the student's work. For example, he may have read or learned that mercuric oxide gives off oxygen and mercury when heated, but unless he has tried the experiment or seen it tried, he could not guess that the powder would become black while hot, and that at a high temperature it would give a yellowish-coloured gas and a small yellow sublimate upon the sides of the tube, owing to the trace of nitrate which the commercial red oxide invariably contains (8-9).

In both of these cases, "free-inquiry" is dominated by watching the teacher, following rules and taking notes. Most importantly, the laboratory is not a space for theory. The detailed procedures to be followed do not leave much room for creative thinking or for historicizing a particular problem. In the progressive vision of a good science education, these were not part of the practices of science. This hyper-empiricist vision of science in schools persists to the present day.

As I suggested before, there appears to be a homology between the relationship between free inquiry/rules of method and freedom/rule of law I identified in progressive thought in general. However, one might object, doesn't "good" science require some structure, otherwise aren't students simply wasting their time? The point, then, is not simply to repudiate structure, method or proper pedagogy, but too reflect on a historically specific set of tensions which operate during this period. Understanding this helps to explain just why progressive thinkers lauded "freedom" and virulently rejected textbooks and other objects of "dogmatic" thought, all the while, laid out detailed procedures for laboratory activities and worked hard to convince their critics that they did not advocate "anarchy." The idea that progressive pedagogy might lead to anarchy was so threatening not simply because it made for a bad education, but because it was related to larger cultural anxieties that the new populist and progressive reforms, particularly those with the intentions of broadening American democracy, would lead to anarchy or worse still, socialism. What made the laboratory so critical in this area is that allowed for a kind of controlled freedom. Furthermore, some of the relations of US life-expert to layperson, knower to known, "regulated interaction," proper "observation"-were widely reproduced (and further reified) in the spaces of the laboratory (Morawski, 1988).

As critical as the laboratory was for doing the work of science itself, it was equally crucial as an expression of the political organization of the kind of liberal democratic society the United States now strove to become. The fetishization of the laboratory functioned as part of the logic of American exceptionalism. As a result of this fetish, as well as the fetishization of technology in general, science education became more concerned with the technical, ironically, making it more mechanical rather than less. Furthermore, a historically specific set of relations between science and democracy was carved out during this period, one witnessed in the writing of Dewey. Science/free inquiry in thought was homologous to democracy/freedom in political life. In fact, one can take this point further. The existence of free inquiry at the level of science practically ensured the existence of freedom in other arenas of social and political life. This is why "mechanical" thought was so disturbing--it was antithetical not only to the principles of science but to the very foundations of democracy, to freedom itself. Ironically, not only was the mechanical rejected, but so was the "theoretical"-science was reduced to "looking" and following instructions which left little room for thinking. Presumably, this is also why a homologous relationship between socialism and dogmatic thought was also presumed by progressive thinkers. Because socialists, and later communists, rejected liberal democratic societies, they were simply not capable of free inquiry and thus trapped in the dogmas of theory.

Fourth Interlude: Science and the limits of Modernity

Modernity developed a critique of itself almost from its inception. While the next chapter will review the development of this critique in the United States and its expression in anti-evolutionary thought and religious fundamentalism, this interlude is intended to introduce readers to the history of such critiques, many of which shape the theoretical a priori's of this dissertation. Even before the "revolutions" of the seventeenth century, Montaigne expressed concern about the possible changes to come. This critical tendency only comes to fruition, however, in the mid-to-late nineteenth century as modernity began to permeate more and more aspects of everyday life. Modernity developed its own self-critique; that is, a critique that begins from the premises of Enlightenment. These self-critical movements are intended to tame modernity, protecting it from its own excesses as well as distracting individuals from the harshness which modern life can bring.

In philosophy, Hegel was the first great theorist as well as critic of modernity-recognizing that the growing division between faith and knowledge lead to a subject estranged from itself-but it was Marx who diagnosed some of the fundamental tendencies of capitalist modernity. Of course, for Marx, capitalism was only the first stage of modernity, a pit stop on the way to communism. In the *Communist Manifesto* Marx famously declared, "All that is solid melts into air," identifying the way in which capitalism revolutionizes all that came before it. Capitalist-modern societies, argued Marx, reject the stasis and respect for tradition of pre-modern societies and are in constant development. They rationalize all processes of production (e.g. commodities, knowledge) and ground knowledge in science rather than religion. While these were aspects of modernity which

Marx, for the most part, lauded, he also recognized the way in which modern society confused relations between people with relations between things, ultimately understanding all social relations through the logic of the commodity (the famous "fetishization" of the commodity in *Capital*). This resulted in a disenchantment of the world and the alienation of the worker from the product of her/his labor. Furthermore, as Marx pointed to presciently in the *Grundrisse,* the extensive production and utilization of science by capital in the form of technology functioned to deskill workers, driving wages down and profits up.

Although Nietzsche was almost always critical of the Hegelian/Marxist tradition, when it came to modernity they shared a similarly critical perspective. Nietzsche admitted that much of his work was an attempt to diagnose modernity and that its sickness revolved around the problems of decadence and nihilism. Nietzsche himself described *Beyond Good and Evil* as, "in all essentials a critique of modernity." For him, decadence was a function of dishonesty. In the case of Western Europe, it was the willingness to treat illusion as reality and endow it with the status of "truth," disguising Christian values, or "slave" values, under the guise of morality. Modern culture had borrowed Christianity's hostility toward life, or *ressentiment*, replacing Christian myths with its own modern or supposedly secular myths like value-free science, democracy and morality. These are the idols of modern life. They reflect a "herd" mentality; in the rush to make all people equal, including equality before a "natural" law, we have resorted to the lowest common denominator. Similarly, nihilism reflects Western culture's disintegration of values, culminating in, as Nietzsche famously put it, "the death of God." For him, the modern age was a sick one.

> ...the haste and hurry now universal, of the increasing velocity of life, the cessation of all contemplativeness and simplicity... [these] are the symptoms of a total extermination and uprooting of culture. The waters of religion are ebbing away and leaving behind swamps or stagnant pools; the nations are again drawing away from one another in the most hostile fashion and long to tear one another to pieces. The sciences, pursued without any restraint and in a spirit of the blindest *laissez-faire*, are shattering and dissolving all firmly held belief; the educated classes and states are being swept along by a hugely contemptible money economy... Everything, contemporary art and science included. The cultured man has degenerated to the greatest enemy of culture, for he wants lying to deny the existence of the universal sickness and thus obstruct the physicians.

Nietzsche's influence was clear in early twentieth century works which sought to find the roots of modernity's failure, texts like Oswald Spengler's *The Decline of the West* (1918) and Heidegger's *Being and Time*, both of which were published after Germany's failures in the war. Each identified, in their own way, the growing sense of many European intellectuals that Western society was on the verge of collapse. But it was Max Weber, witnessing the collapse of the ethical spirit of bourgeois liberalism in fin-de-siecle Europe, who best captured the relationship between the critique of modern life and science.

Weber's well known argument in *The Protestant Ethic and the Spirit of Capitalism* (1958) was that the "rationalization" of the world led to a secularization of culture, a delegitimation of a religious worldview, and eventually the rise of bureaucratic institutions and instrumental rationality. Weber's thesis was that a particular kind of rationality dominates modern life. It involves a range of activities from the depersonalization of social relationships, the refinement of techniques of calculation and the enhanced importance of specialized knowledge to, perhaps most importantly, the extension of technical-rational control of both the natural and social. This kind of rationality, particularly its impersonality, lead Weber to refer to modern capitalism famously as an "iron cage." Weber made an important distinction between formal and substantive rationality, which Max Horkheimer later developed into a full fledged critique of instrumental reason. Instrumental rationality and formal rationality are the same. They seek simply to maximize the calculability of action as an end onto itself. They calculate and rationalize for their own sake. They are means-ends driven. It is a model, Weber argued, developed from the logic of the market. This does not mean they have no goals. As Weber pointed out in *Economy and Society* (1968), they are used "as 'conditions' or 'means' of the actors own rationally pursued and calculated ends" (24). But, it is self-interest (individual or even group) that guides rationality, because in a disenchanted world, this is the closest people can come to a sense of real purpose or meaning. Substantive rationality, in contrast, is driven by purpose. It thinks in the service of an ethics, instilling the world with meaning. The dominance of formal rationality, thus subjecting all models of life to a rationalization without meaning, is a strategy of domination, and is for Weber, the essence of bureaucratization.

It is not hard to see how science fits into all of this. By providing specialists with technical knowledge, science aids in this system of calculability. It can no longer lead the battle against dogmatism, as, in the iron cage of the modern world, its instrumentalization, by definition, disavows a sense of value. Science is now practiced for its own sake. Max Horkheimer and Theodor Adorno in their *Dialectic of*

Enlightenment (1944), take this position a step further. Enlightenment and science themselves have become the myths they purport to fight. The "quest for truth" allows science to pretend to transcend the everyday, but in reality, it simply naturalizes the everyday. Both authors witnessed the development of fascism in Germany and came to identify authoritarianism as a natural outgrowth of Enlightenment rather an aberration.

In *Eclipse of Reason* (1947), Horkheimer revived Weber's distinction of types of rationality and distinguished between subjective and objective reason. Subjective reason, like instrumental rationality, is concerned with means and ends, its purposes are more or less taken for granted and it is self-satisfied with its own logic of existence. This is modern science, the science we seek to teach children in schools. It no longer needs to justify itself on any grounds higher than its capacity to tinker with nature and human beings as well as perform calculations. In contrast, objective reason regards,

> The existence of reason as a force not only in the individual mind but also in the objective world... It aimed at evolving a comprehensive system or hierarchy, of all beings, including man and his aims. The degree of reasonableness of a man's life could be determined according to its harmony with this totality. Its objective structure, and not just man and his purposes, was to be the measuring rod for individual thoughts and actions (Horkheimer, 1947, p. 4).

Objective reason is the foundation of what I've termed a critical science. The ancient world was rife with purpose. It was the formalization and subjectivization of reason in Enlightenment thinkers like Locke, Hume and Kant, who transformed objective into subjective reason. As Enlightenment waged war on the non-rational--myth and religion--it relegated purpose and meaning to the realm of faith and dogma. Not long afterwards, its next victim would be philosophy and all speculative thought in general. Science, like reason, "...has liquidated itself as an agency of ethical, moral and religious insight" (ibid, 18). It is left only with technical advance and the reproduction of bourgeois ethics, particularly its dependence on a society obsessed with consumption.

Aesthetics and the Critique of Modern Life

Some of the most devastating critiques of modern life came from late nineteenth and early twentieth century European aesthetics. As with science, the radical promise of modern aesthetics, which would develop over the nineteenth century, would also be co-opted by the bourgeois world, stunting what began as a radical critique of modern life. Baudelaire took direct aim at modernity's fetishization of progress in his "On the Modern Idea of Progress as Applied to the Fine Arts" (1855).[1]

> There is yet another and very fashionable error which I am anxious to avoid like the very devil. I refer to the idea of "progress." This obscure beacon, invention of present-day philosophizing, licensed without guarantee of Nature or God... Anyone who wants to see history clearly must first of all put out this treacherous light... Take any good Frenchman who reads his newspaper in his café, and ask him what he understands by progress, and he will answer that it is steam, electricity, gaslight, miracles unknown to the Romans, whose discovery bears full witness to our superiority over the ancients. Such is the darkness that has gathered in that unhappy brain!

Prefiguring Nietzsche, Baudelaire went on to declare, "Such an infatuation is a symptom of an already too visible decadence." Baudelaire also introduced what became a central theme in aesthetic-based critiques of modernity, or modernism, and that is that it is only

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[1] Baudelaire's "The Salon of 1846" and "The Painter of Modern Life" both identified one key sense of modernity. "Modernity is..." Baudelaire wrote in "The Painter of Modern Life" (1863), "...the transitory, the fugitive, the contingent... in a word, if a particular modernity is to be worthy to become antiquity, it is necessary to extract from it the mysterious beauty that human life involuntarily gives to it." In Baudelaire, one finds one of the pivotal contradictions of modern life, the simultaneous search for fashion and beauty—put more broadly, between the transient (aesthetics, fashion) and the permanent (epistemology, science), sometimes in the same object. Furthermore, for him, beauty is characterized by its quality of being present. While modern life is not itself beautiful, it is the job of the modern artist (the *flâneur*) to find beauty in it, to capture these ephemeralities. Moreover, it is the function of the artist to distract us from the crassness of everyday life, taking us into a different world, one that only s/he can help us find.

in art that one can transcend modern life. While modernism in art finds its roots in romanticism, it rejects romanticism's a priori rejection of the Enlightenment, and instead, slowly comes to recognize that bourgeois culture's sense of its own Enlightenment is profoundly in error and perhaps even deserving of ridicule. It is entirely too self-satisfied and unaware of its own failures. The artist alone can step outside the commercialism of modern life and produce independent, creative work able to reflect on the problems of modern life. For these artists, the more "outrageous" they were, the less they were likely to be accepted and hence corrupted by bourgeois values.

In France, the critiques making up modernism were taken up by the *avant-garde*, who implied in their critique of aesthetic forms a broader critique of social forms. In the case, for instance, of Arthur Rimbaud, his critiques of poetry forms were situated in the context of his critiques of modern bourgeois life and his support for the Paris Commune (Calinescu, 1987). In the realism of Émile Zola's *Germinal,* one comes to see how working-class miner's lives are made miserable by the dominant classes of French society. Even Joseph Conrad's *Heart of Darkness* can be read as a critique of Western society-while at the same time, of course, fetishizing the African "Other." Gradually, however, the lines of social and aesthetic critique diverged and the artist found refuge in the world of art, increasingly supported by a bourgeois culture which also took refuge in art. Carl Schorske, Allan Janik and Stephen Toulmin all find this to be the case in their respective studies of fin-de-siecle Vienna.

As Janik and Toulmin (1973) put it, for the fin-de-siecle generation "art became a way of life." Further, "If the generation of the *Gründer* held that "Business is Business" and art is essentially the ornamentation of (business) life, their sons for whom art was essentially something creative, retorted that "Art is Art" and business is a tedious distraction diverting one from "artistic" creation" (45). While the art of the previous generation had been oriented toward the values of the past, a sign of bourgeois success, the new art was forward-looking and innovative, seeking to reject the "liberal" society within which its creators were raised. Schorske (1981) makes a similar point in his study.

> By the end of the century, the function of art for Viennese middle-class society had altered... If the Viennese burghers had begun by supporting the temple of art as a surrogate form of assimilation into the aristocracy, they ended by finding in it an escape, a refuge from the unpleasant world of increasingly threatening political reality... The life of art became a substitute for the life of action. Indeed, as civic action proved increasingly futile, art became almost a religion, the source of meaning and the food of the soul" (8-9).

What philosophy had been to the German idealists of the early nineteenth century, art became for bourgeois society of fin-de-siecle Vienna (Ringer, 1991). It is ironic that the bourgeois itself and those that sought to attack bourgeois values-artists who were generally raised in middle-class society-all found themselves drawn to the same art. It was in this environment in that Arnold Schönberg began his critique of tonality, itself a critique of the pseudo-sophistication of bourgeois aesthetics and that Gustav Klimt, in 1897, along with nineteen students, withdrew from the Academy (following the lead of the French Impressionists) and formed "the Secession," rejecting doctrinal art and instead advocated "freedom," seeking to speak the truth about modern society. Ironically, it was only a few years later that Klimt's work was institutionalized by the Viennese art world.

The more divorced aesthetic critique was from political critique the more modernist movements in art simply opened with a critique of their own ground. For instance, the novelty of Impressionism had been to explode the rules of perspective inherited from Renaissance art while Picasso and his fellow Cubists, influenced by the developments in physics (the X-rays, relativity theory), sought to capture the world from multiple perspectives simultaneously, transcending the spatial and temporal limitations of art (Kern, 1983). These movements rejected traditional representations of human forms as evidenced, for example, by the Futurist declaration that they would use the new discoveries of science to create new art forms or Marcel Duchamp's designations of "ready-mades" as art. In many of these cases, the aestheticization of criticism allowed for easy co-opting by a bourgeois hungry for the new and quite ready to poke fun at its own conventions. Furthermore, along with an aestheticization of social criticism there was a subjectivation of critique; in other terms, suffering was transformed from a reflection of a particular set of historical conditions to an exclusively subjective and intra-psychic phenomenon.

While early modern writers tended to position themselves within the Kantian critique, in other words, seeking to identify the limits of rationality, in the period after the first world war, many writers and artists, influenced by Freud, Nietzsche, as well as the devastation of the war itself, inaugurated a full fledged assault against rationality. Thus, Marx, Nietzsche, Weber, and even Freud himself, should be regarded as exemplars of the former, seeking to identify the limits of Reason so that its right to theorize the world could be vindicated (Hughes, 1957). In contrast, the Surrealists were less interested in preserving a space for Reason than celebrating its antitheses, all in the service of their own radical politics. As opposed to simply reflecting on reality, the Surrealists sought to reinvent the terms of reality as they came to believe neither that reality could be "reflected," nor that there was any value in this in the first place. The Surrealists sought to explore the "unconscious" in ways that had been prefigured by artists like Edvard Munch and Gustav Klimt. The case of Bergson, probably the most influential philosopher of the first decades of the twentieth century, is more complicated. His revival of intuitionism-his idea that the natural sciences tend to spatialize life/matter and its is only through intuition that could life be captured in its own qualitative temporalities, in *dureé*-while not necessarily anti-rationalist, certainly had the effect of subordinating the "empirical" sciences to more intuitive-based knowledges and suggesting a new, non-rationalized conception of time which was then taken up by many modernist writers (e.g. Joyce in *Ulysses*). Writers ranging from Thomas Mann to Herman Hesse and Franz Kafka all sought to capture, in one way or another-quite literally in Mann's *The Magic Mountain*-the intellectual and spiritual sickness that seemed to emanate from the heart of European thought.

Even Freud, who was undoubtedly invested in the Enlightenment project, set the stage for its undoing by denying the existence of rationality qua rationality (as it is always a cover for something else) and even calling into question the twin projects of science and liberalism by suggesting that science's quest for certainty was a reflection of a deeper, non-reason-based, intra-psychic form of wish fulfillment. Interestingly, for many of these European thinkers, the "revolt" against Reason led them to religion. This was the case with Bergson, a devout Catholic, whose last work, *Two Sources of Morality and Religion*, was devoted to religion, as well as other influential intellectuals of the period like Charles Péguy, and even, despite the fact that he was open about his homosexuality, André Gide. Even Max Plank complained of this fact,

> precisely in our age, which plumes itself so high on its progressiveness, the belief in miracles in the most various forms-occultism, spiritualism, theosophy, and all the numerous shadings, however they may be called-penetrates wide circles of the public, educated and uneducated, more mischievously than ever, despite the stubborn defensive efforts directed against it from the scientific side (cited in Forman, 1971, p. 12).

Modernity was able to tolerate these aesthetic critiques of its own sense of Enlightenment, but when similar critiques sprung out of the sciences themselves, they had the effect of destabilizing the sense of certainty inherited from the seventeenth and eighteenth centuries. Much of these developments took place in German physics. On one hand, the results of late-nineteenth century physics itself-the development of x-rays, the Michelson-Morley experiments, which later impelled Einstein's work on relativity, Planck's discovery that energy could only be emitted and absorbed in discrete "quanta," the seemingly contradictory "wave" and "particle" theories of light and the "complementarity" hypothesis which sought to resolve the contradiction-seemed to indicate that the Newtonian paradigm could only explain a limited set of phenomena, or worse still, that it was on the verge of collapse. On the other hand, the post-war culture of Germany and the anti-science (and in particular anti-causality) cultural aesthetic that developed following Germany's loss in the war, as Paul Forman (1971) has demonstrated, led many physicists to publicly reject the determinism and mechanism of the Newtonian paradigm and begin to develop a new one, resulting in the quantum theory.

One of the most popular works of the day, Oswald Spengler's *Decline of the West,* declared that scientific theories were "culture-bound illusions" and "anthropologically preformed myths." Given this environment, Forman argues, it should not be surprising that physicists began to develop speculative theories which rejected the determinism of the Newtonian paradigm. In the new physics, the certainty of Newtonianism was replaced by statistical regularities and probabilities, and worse still, Heisenberg's full-fledged "indeterminacy." Even the *London Times* in 1919 was ready to proclaim "Revolution in Science: New Theory of the Universe: Newtonian Ideas Overthrown" (cited in Cantor, 1988, p.100), Of course, not everyone was convinced. Einstein became the most famous holdout, refusing to believe that "god played dice with the universe." Einstein recognized just how revolutionary these new ideas were and how they fundamentally challenged, not only our understanding of the world, but the scientific project itself. In the 1920s, many philosophers sought to deal with the major ontological and epistemological implications of this new paradigm-examples included Whitehead's *Process and Reality* and Dewey's influential Gifford lectures published as *The Quest for Certainty* in which he grounded the results of science in "practice" rather than certainty. This culture, ambivalent about modernity, was the one from which the battle against evolution and the right of science to legislate theories of value, sprang.

Chapter Four: Fundamentalism as Social Critique

In this chapter, I will focus on the infamous "Monkey" or Scopes trial of the 1920s, where US public school teacher, John Scopes, was tried and convicted for teaching evolutionary theory in a Tennessee school. The trial captured the imagination of many in the US, a reflection, according to many in the religious world, of a critical stand against a godless science. Others in the United States, particularly the media, came to regard those that sought to prosecute Scopes as religious absolutists opposed to the march of science. But, rather than reading the trial as simply a religious or anti-science phenomena, which it surely was, I will situate in the broader context of the strain of anti-modern and anti-Enlightenment thought which I identified previously (Fourth Interlude), one that accompanied modernity from its inception and became more widespread in the early years of the twentieth century. In other words, rather than dismissing those that opposed the teaching of evolution as religious zealots, it is more appropriate to recognize their relation to a larger protest against modernity, a protest which was exacerbated by, what many came to regard as a "soulless" culture and a declination of values. In other words, one finds a position which argues that the scientization of US culture had left it for the worst. While in Western Europe these feelings tended to express themselves mostly in philosophy, literature and art, though they affected science as well, in the US, some of this was reflected in the rise of Protestant fundamentalism. What is fascinating about the cleavage in Christian thought precipitated by the rise of fundamentalism, was that in certain respects, it was fundamentalism that developed a more critical perspective on modernity--after all, as I will point out, it was they who held on to the democratic principle that all people had equal access to God and thus did not require expert mediation for salvation.

1. Modernity and the Rise of Fundamentalism

Modernity and religion had a peculiar relationship which could be antagonistic at times, and yet, in order to understand their relationship, one must move beyond the idea that they were inherently opposed to each other. They were quite dependent on each other. Religion often symbolized the pre-modern past from which modernity broke and the co-existence of religion allowed modernity to express its own modern-ness. Furthermore, religion depended on modernity to exemplify what happens to a society when it loses touch with God.

It would be fair to acknowledge that all religions in the United States, particularly after the First World War, had to deal with what appeared too many as a "secularization" of society. As Walter Lippmann explained in his best-selling *Preface to Morals* (1929), many people stopped attending Church because they were no longer sure that it was there that they would find God and modern life could no longer support the kinds of fixed belief that religion encouraged. Paradoxically, in this period, when one looks at the numbers, church attendance actually increased. Given the effect that the many new immigrants had on American life, especially given the fact that many of them were Catholic and resented Protestant domination of US culture, Protestantism experienced the most serious crisis in terms of the effects of "secularization" which they regarded, and not completely without merit, as a de-Protestantization of American society. Given the

Progressive movement's Protestant character-especially evident in Prohibition which was largely a Protestant attempt to impose their own mores on working class, Catholic immigrants-it was not surprising that many non-Protestants resisted the imposition of Protestant values on their lives, especially when Protestants conflated Protestantization with Americanization, which was frequently the case in their dealing with immigrants.

But, there was more going on in this period for Protestants than conflicts with Catholic immigrants. Protestants faced a growing cleavage within their own ranks. While Protestantism had always been denominational, new sects emerged (e.g. Holiness, Pentecostals) in reaction to the seeming adaptation of some Protestants to modern life (e.g. Unitarians, Methodists). Most important in terms of this study was the emergence of Protestant fundamentalism in the 1910s and 1920s and its growing battle with liberal Protestantism. As noted in a previous chapter, Protestant liberalism had already upset many Protestants sects by accepting the results of the higher biblical criticism which emerged from Germany, by implication, rejecting what had become one of the key foundations of American Protestantism, the literal interpretation of the bible. Further, and perhaps just as important, by requiring that only an "expert" in hermeneutics could reveal the "truth" of the bible, liberal protestants rejected a second key foundation of American Protestantism-the democratic principle that all individuals were capable of reading and understanding the bible on their own, a part of their very personal relationship with God.

Protestant liberalism offered its own fundamental changes to traditional Protestant theology. Gone were the doctrines of human wickedness, the exclusiveness of Christian revelation and a transcendent, all powerful God. These ideas were slowly replaced by a God that was immanent in nature, a more optimistic conception of humanity and the idea that many, alternate religious paths led to God (Hutchison, 1976). During the nineteenth century, the Unitarians and Transcendentalists, while not necessarily friendly to modernity-in this regard, one should note Henry David Thoreau's expressed criticisms of technology-were open to judging and transforming their doctrines through the standards of eighteenth century rationality. Thomas Paine's *Age of Reason* went the furthest in developing a new notion of immanence that he hoped would protect religion from the threat to compulsive systems engendered by the French Revolution. But, by the middle of the nineteenth century, it became more acceptable among these groups to deal with the latest results of philosophy (first taking up idealism and later pragmatism) and comparative religion, as well as to consider adapting theology to this new age, as was the case in Octavius Frothingham's influential *Religion of Humanity*. Beginning in New England Congregationalism after 1875 and taking hold in many Methodist, Baptist and to a less extent Presbyterian and Lutheran congregations in the 1880s and 1890s, a new theology was born (Hutchinson, 1976). These ideas were made popular and systematized through the much read writing of Washington Gladden, Lyman Abott's *Christian Union*-which had a readership of over 100,000 by the turn of the century-and later Walter Rauschenbusch's *Christianity and the Social Crisis* (1907).

With the success of the Social Gospel and the progressive logic it adapted in the early part of the twentieth century, liberal Protestants were very visible. The Progressive movement itself had strong Protestant undertones and generally took for granted its particular understanding of morality. While Protestantism traditionally had an individualistic focus, writers like Walter Rauschenbusch extended Jesus' project from salvation of the individual soul to salvation of the human race. Because the vices and inequities of modern society could frustrate this work, it was the job of the good Christian to intervene. Both conservative and liberal Protestants stressed this new social gospel-this was particularly true in the case of conservative Protestants in the American South, where liberal Protestantism did not make much headway. However, because liberal Protestants regarded God as immanent in all social life, they were generally more comfortable working with secular organizations.

Conservative Protestant theology was influenced by the theology of Charles Hodge and others at the Princeton Seminary as well as the revival of premillennialism after the civil war. By 1895, conservative Protestantism agreed on five basic points: (a) the inerrancy of the Bible, (b) the divinity of Christ, (c) the virgin birth, (d) the substitutionary atonement of Christ and, (e) the resurrection and eventuality of the second coming (Sprague de Camp, 1968). Just before the war, the many strands of conservative Protestant theology were united in a series of twelve booklets, published through the efforts of Lyman Stewart from 1909 to 1914, which sought to lay out the "fundamental" tenets of, what would now be termed, Fundamentalism. Interestingly, it was not evolution that received the most attacks, but the higher criticism. Evolution would not become a major issue for fundamentalists until the 1920s. Ironically, in these booklets, which came known as *The Fundamentals,* some major progressive concerns were expressed: illegitimate sources of wealth, the misery of the poor, even the importance of education for all (Larson, 1985).

The war acted to further ignite the spark of fundamentalism as many premillenialists truly regarded it as the beginning of the end of the world and the second coming of Christ. In addition, the war vilified all thought emanating from Germany, including biblical criticism. After the war, certain cultural crises, particularly the red scare of 1919, further alarmed fundamentalists, for some, exacerbating their apocalyptic notions and convinced them that modernity and liberalism had to be confronted directly (Mardsen, 1980). This led to a series of conferences organized by William B. Riley devoted to halting some of what he regarded as degenerative social trends, uniting fundamentalists from across the country. These conferences inaugurated the Fundamentalist controversies of the 1920s, moves to rid the church and culture of its modernist leanings. These would include a diversity of movements including the rise of the Klu Klux Klan, prohibition, the Scopes trial and the campaign against Al Smith in 1928.

It is important to note that it was not only conservative Protestants who identified these years as ones of "controversy," as liberal historians of the period wrote widely disseminated works which characterized the relationship between science and religion as one of "warfare" and did much to convince the general populace that, indeed, science and religion were fundamentally opposed to each other and had been for a long time (Draper, 1926; White, 1896). The secularist position of these authors repeated the well-worn narrative that since the seventeenth century science had gradually emancipated itself from the dogmatisms of religious thought. Furthermore, liberal Protestants themselves mounted an offensive against conservatives in journals like *The Biblical World* and

Christian Century, seeking to rid Christianity of what they regarded as defective beliefs and habits like premillenialism, denominationalism, and revivalism (Marsden, 1980).

By 1921, the battle against evolution became the primary focus of conservative Protestantism's battle against liberalism and modernity (Szasz, 1982). While there are many reasons to explain this shift, religious historians generally agree on four. First, with the spread of public high schools, more and more American youth were taking biology classes, and thus learning about Darwin and evolution, particularly after 1912 and the discovery of the "Piltdown hominid" which inspired the *New York Times* to declare "Darwin Theory is Proved True" (cited in Larson, 1985, p.13). Second, these years saw the early formulations of a new focus in evolutionary thought which would replace the more religious-friendly "Lamarckism" with Darwinian natural selection as the guiding force of evolution. Third, after the war, which many in the US attributed to the spread of "Nietzscheanism" and his supposed evolution-inspired doctrines about a race of *übermensch*, European thought, including Darwinism, came to be regarded as anti-democratic and without any sense of value. Finally, on a related point, the very ideas of survival of the fittest and competition for resources came to be regarded as anti-democratic and in opposition to the new progressive spirit of the times. This would become one of the principal arguments of William Jennings Bryan's campaign against evolution.

2. The Problems with Modern Life in America

Fundamentalists were not the only ones to have difficulties with some of the changes precipitated by the modern world in US society. Turn-of-the-century Europe developed some of the most innovative aesthetic movements in the history of the West to convey its dissatisfactions with modernity. It was hard not to take note of these changes, as Virginia Woolf attempted to convey when she announced famously, "On or about December 1910 human nature changed." In the US, the muckraking tradition was an influential mechanism by which US cultural taken-for-granteds were debunked as was the Progressive movement in general, but they tended to focus more on the power of business and the social problems that came from immigration, urbanization and industrialization rather than offering a critique of science/technology per say, or modern culture in general. In painting, it was only in the 1940s, in the works of artists like Jackson Pollock and William de Kooning, that one could see the influence of European aesthetic Modernism. Some of the most memorable critiques of modern life came out of the burgeoning film industry, in movies like King Vidor's *The Crowd* (1928), *Safety Last* (1923), and many Chaplin films.

One of the more explicit critiques of US society could be found in Sinclair Lewis's *Babbitt* which took direct aim at the valuation of conformity and consumerism in American life. Moreover, there were several other American writers, most of whom spent some time in Europe, who took up similar themes. One of the more well-known groups of US intellectuals who shared a similar critique of modern life was one that Gertrude Stein labeled the "Lost Generation." Some of its most famous members, like Ernst

Hemingway and F. Scott Fitzgerald, highlighted the aimlessness and dearth of meaning in modern life in novels like *This Side of Paradise* and *The Sun Also Rises* as well as took direct aim at the superficiality of upper middle class life in *The Great Gatsby*. Hemingway's melancholic perspective-especially evident in a character like Jake Barnes-like many others in this group, was profoundly shaped by the war (in which he volunteered to drive ambulances) and the death and brutality he witnessed. While most Americans in this period tended to value technology and progress, some critics-for instance Carl Sandburg's poem "Smoke and Steel" (1920) or the some of the paintings of Charles Demuth-sought to identify its cost to US culture and people.

Consumerism tended to be a visible target of US modernist writers, especially as compared to Europe. It was simply impossible to miss the influence of consumer culture in the US, particularly by the 1920s. From Henry Ford's speeding up production of his "Model A's" by introducing the assembly line, to the spread of spectator sports, nightclubs and other recreational activities, as well as the beginnings of "Hollywood," consumerism was quite visible. American expenditures on recreation increased by 300% during the 1920s (Dumenil, 1995). These years saw the growth of the advertising industry in general as well as "celebrity" advertising campaigns. Many Americans began to measure their self-worth more and more by what they possessed than by what they did. As Lynn Dumenil points out, this tendency was related to the routinization and mechanization of the workplace, which was no longer able to provide individuals with a sense of accomplishment or self-worth. In addition, the growing advertising industry tended to equate consumption with modernity itself, communicating to individuals that they need purchase the "latest" convenience, while at the same time, exploiting anxieties about modern life (Leach, 1993). But, the growth of advertising was more than this. It was a moment wherein people's education was extended to include the logic of consumption. As business created wholly new sets of "wants" and "needs," people were taught that they could ameliorate social and personal frustration through consumption. As Stuart Ewen (1976) points out, this was a self-conscious strategy on the part of industry. Furthermore, Ewen argues, the growing scientism in education, with its focus on "facts," corresponded to the growing desire on the part of industry to have workers come to understand themselves through the lens of a "machine age," one which would be intimately tied to consumption. This provided yet another incentive for business to enter debates on education.

3. Scopes and its Aftermath

Although William Jennings Bryan was probably the most responsible for stirring up the passion of fundamentalists against the teaching of evolution, it is interesting to note that Bryan was relatively tolerant of evolutionary ideas for the first two decades of the twentieth century even declaring that he "did not mean to find fault with you if you want to accept the theory [of evolution]; all I mean to say is that while you may trace your ancestry back to the monkey if you find pleasure or pride in doing so, you shall not connect me with your family tree without more evidence than has yet been provided (cited in Larson, 1985, p.20). It appears that the war was a catalyst for his transformation. Bryan had become a leader of the populist movement by the late nineteenth century and electrified that nation with his speech to the 1896 Democratic National Convention-fighting for an alternate, silver-based currency (to ease the burden of debtors) and later against US imperialism and militarism. From then on, he became widely known as the "great commoner," becoming one of the few influential politicians of his day who stressed the ethical content of economic and social problems (Coletta, 1969). Many of Bryan's suggested reforms would later be incorporated into the New Deal. During his tenure as Wilson's Secretary of State, Bryan became opposed to the government's pro-war policy and eventually resigned. Before the US's entry into the war, he vocally campaigned for peace, but after the US entered the war, he kept his anti-war views private and even offered to serve in the army.

In 1916, Bryan read and was influenced by Benjamin Kidd's *The Science of Power*, which argued that the writings of Nietzsche, by taking Darwinism to its logical conclusion, inspired German militarism. By the early 1920s, Bryan began to state publicly that he regarded Darwinism as undermining the moral foundations of the Christian faith and had inspired the world's most destructive war (Szaz, 1982). He was warned by some of his friends and colleagues that his crusade against Darwin would lose him the respect of many in intellectual circles but he persisted (Coletta, 1969). His anti-Darwinism lectures were published as *In his Image* and sold over a hundred thousand copies, transforming Bryan into the leading opponent of evolution and making him into a spokesmen for the "silent majority" of Americans who were suspicious of Darwinism and took the biblical story of creation literally. This is not to suggest that Bryan's views did not divide the Christian world. From 1922 to 1924 he was repeatedly responsible for much in-fighting at the General Assembly of the Presbyterian Church of the United

States of America when he insisted that they adopt his anti-evolution stance (Coletta, 1969).

As Liberal Protestants criticized Bryan, he, along with another leading fundamentalist leader, William B. Riley, used his speeches to inaugurate a movement bent on using legislation to outlaw the teaching of evolution. Bryan circled the country offering anti-evolution speeches to towns and cities that were considering adopting similar legislation. Although fundamentalists happily accepted Bryan as their champion, technically they differed on many theological issues. Bryan was not a premillenialist, nor was he interested in removing the church from a sinful world, as Riley was. He was more interested in bringing the "spirit" of Christianity to the world, which was, as Szaz points out, a traditionally "liberal" position. Finally, even with respect to his anti-evolutionism, Byran differed from his fundamentalist allies. He was not interested in imposing a penalty on those who taught evolution, expecting that a law enacted by a legislature would be enough. In 1921-2, the first anti-evolution bills were defeated in the Kentucky legislature by one vote as well as in South Carolina. By 1923, Bryan speeches were instrumental in getting the first few anti-evolution laws passed in Oklahoma, Florida, and by 1925, in Tennessee.

After the Tennessee law was passed, some citizens of the town of Dayton suggested the idea of having a popular teacher named John Thomas Scopes brought to trial for violating this law. Scopes had used Hunter's *Civic Biology* in his classroom (only once as he was not the school's regular biology teacher) which included sections on the life of Darwin, natural selection and genetics. The ACLU, an organization originally established to protect the civil rights of those against the war and had recently broadened its focus to protect civil liberties in general, regarded the Tennessee law as a violation of the First Amendment and placed an ad in the *Chattanooga News* in which they offered to pay the legal fees of any teacher willing to challenge the law. Some of Scopes fellow townspeople convinced a reluctant Scopes to participate. When Bryan received news of the case, he offered to prosecute without charge, even though he had not been in a courtroom in almost thirty years. Bryan's entrance into the case incited Clarence Darrow, a leading proponent of civil liberties (he had defended professed communists during the "red scare" several years before and saved Leopold and Loeb from execution) and, in the 1898 election, a former supporter of Bryan, to join the case on the side of the defense. News of the case quickly spread around the country and came to be regarded as the great battle between scientific/modern skepticism and traditional faith. Rarely was the idea discussed, especially by the press, that many in the scientific community accepted theistic versions of evolution (Layton, 1998). While these was some truth to this over-simplified characterization (Darrow was a professed agnostic and was openly hostile to religion as he demonstrated to many through his motion to suppress a prayer in the courtroom at the Scopes trial), the truth, as one might expect, was far more complicated.

While later re-tellings of the Scopes trial, particularly the play (later made into a movie) *Inherit the Wind*, tend to portray Bryan and his fellow fundamentalists as religious fanatics trying to impose their view on others and halt the progress of science, Bryan's view was far more complex. Even one of the great historians of the period, Richard

Hofstadter criticized Bryan for his activism in his later years, characterizing him as a broken, reactionary figure. He goes as far as to unfairly explain the motivation of the fundamentalists as based in a fear that their children will be smarter than themselves, a part of what Hofstadter identifies as a "quickening of the pulse" of anti-intellectualism in American life (Hofstadter, 1962, p.130). In fact, Bryan's position was an extension of his populist ideas of the late nineteenth century. Bryan argued that it was the majority opinion not a small class of experts that should determine what children needed to learn in schools. Because more people in the state of Tennessee, in fact, in the entire country, accept the biblical account of creation, democratic principles dictate that their ideas should determine the version of the origin of life taught in schools. While many ridiculed Bryan for suggesting that all common-people can regard themselves as "skilled biologists," Bryan possessed a fundamental trust in the capacity of people to deal their own epistemological, social and political questions (Coletta, 1969).

Further, for Bryan, evolution suggested that major change was always gradual, and thus, went against his belief in the importance of immediate social reform and "discourages those who labor for the improvement of man's position" (cited in Szaz, 1982, p. 129), culminating in the kinds of determinisms one found in the IQ and eugenics movements. Furthermore, because Darwinism was not neutral on the creation question, but actually undermines the Bible, evolutionary ideas were intent on subverting the religious belief of a majority of Americans. If Christ was simply another human, "descended from monkeys," then how could faith in him offer salvation? In contrast to some of his fundamentalist allies, Bryan did not necessarily seek to have creationism replace evolution; he simply wanted schools to exclude both doctrines, making educational institutions neutral on this profoundly religious question rather than promulgating an anti-religious view. At times he took an even more liberal position, asking that evolution be taught only as a "theory" rather than a "fact."

The trial eventually became something of a circus. A sign over the local meat market declared "WE HANDLE ALL KINDS OF MEAT EXCEPT MONKEY" (Sprague de Camp, 1968). Much of the media in the US used the opportunity to ridicule Bryan and the fundamentalist position in general. H.L. Mencken argued in the *Nation* that the people of Tennessee has a right to teach whatever they wished, after all, a democracy had a right to make itself look as foolish as it could (Szaz, 1982). The president of Columbia University, Nicholas Murray Butler, referred to the antievolutionists as "the new barbarians storming the citadels of learning" (Larson, 1997, p. 111). As Larson notes in his study of the trial, Butler's proclamation set the tone for the liberal response to the trial: fundamentalism threatened to reverse the progress of Western civilization since the Enlightenment and the battleground was Dayton, Tennessee! Of course, scientists out and out rejected Bryan's populist position and argued that scientific decisions were never based on votes but on careful examination of evidence. While accepting the integrity of the fundamentalist position against evolution, many in the South resented the trial and the reaction of the media, as not since the days of the Civil War and Reconstruction had the image of the people of the South been so debased.

The prosecution charged Scopes with two offenses: (1) teaching a theory which denied the biblical account of creation and, (2) teaching that humans descended from lower animals. To this, the defense accepted the second charge but rejected the first; in other words, they sought to demonstrate that one could accept evolution and the biblical account of creation at the same time (Sprague de Camp, 1968). Scopes himself was virtually invisible throughout the trial and the scene that captured the public's imagination the most was Darrow's cross examination of Bryan on the witness stand, which many came to regard as Bryan's ultimate humiliation, even a possible cause of his death several days after the trial ended. After calling Bryan to the stand, Darrow sought to reveal the inconsistencies of his knowledge of the bible. "Did the whale really swallow Jonah," Darrow asked. And later, "Do you believe Joshua made the sun stand still?" "I accept the Bible absolutely," Bryan replied. To which Darrow responded victoriously, "Now, Mr. Bryan, have you ever pondered what would happen to the earth if it has stood still… don't you know it would have been converted into a molten mass of matter" (cited in Larson, 1997, p. 4). In the end, even Bryan admitted that he did not always take the Bible literally. Although Scopes was declared guilty of violating the law and fined $100, Bryan's testimony has been regarded by many as an illustration of the failure of the fundamentalist position. Because the defense sought to take the case all the way to the US Supreme Court in order to have the law declared unconstitutional, they regarded their loss as a victory; however, in the appellate process, the Tennessee high court reversed the ruling because of a technical error on the part of the judge in the Scopes case, making appeal to the Supreme Court impossible and, as far as the ACLU was concerned, ending the case prematurely.

Many historians have come to regard the Scopes trial and Bryan's death as the definitive end to fundamentalist attacks on evolution in this period-some even going so far as to suggest it was the "death blow" of Protestant Fundamentalism altogether-but that was far from the case; in fact, the truth is quite the opposite. The Scopes trial inspired a fresh round of anti-evolution legislation and, although there was a decrease in fundamentalist activity by the end of the decade, it was more likely due to their victories rather than defeats. Much of these erroneous conclusions about the trial were influenced by works like Fredrick Allen's *Only Yesterday*, William Leuchtenburg's *The Perils of Prosperity*, Hofstadter's *Age of Reform*, and the play and motion picture versions of *Inherit the Wind*. All of these, in one way or another, characterized the trial as a battle between scientific skepticism and fundamentalist dogma, as well as a battle between Northern cosmopolitanism and Southern backwardness, in which the former prevailed. Although the play was intended to be read as an indictment of McCarthyism, what viewer of the movie *Inherit the Wind* could forget Spencer Tracy's "Drummond" humiliating "Brady" on the witness stand, almost making him weep as his began to doubt his own religious beliefs (though in real life, the scene took place on the lawn of the courthouse as there were too many spectators to accommodate inside the small courthouse).

Interestingly, many reviewers criticized the play for its caricature of the fundamentalist position, especially its depiction of Bryan as a mindless reactionary, but by the time the movie was widely seen, the demise of McCarthyism and the beginnings of a new religious right made reviewers more sympathetic to the dangers of fundamentalism and the movie's depiction of the fundamentalist position was accepted as accurate. As I have suggested, while many regarded the trial as providing a fatal blow to the fundamentalists, there is much evidence to the contrary. In addition to the new round of anti-evolutionist legislation-new anti-evolution legislation was introduced in Georgia, Texas, and over fifteen other states (Larson, 1985)-George Hunter's *Civic Biology*-the text used by Scopes-in addition to many other biology texts, either deleted mention of evolution from the text entirely or produced new editions which referred to evolution as only a "theory" or "hypothesis." Furthermore, the years following the trial saw the beginnings of what is now called "scientific creationism" (Numbers, 1992) and a dramatic increase in fundamentalist schools and universities across the country.

As I have been arguing, the Scopes trial was about far more than just the role of religion in schools or religious fanaticism (not to suggest that it was not, at times, about some of these things), but it was a reaction to a broader ambivalence around modernity and the rising influence of scientific experts during the Progressive period. What the higher criticism did to the bible, evolutionary theory did to the origins of life. Opponents of both of these "modern" ideas refused to accept that they now had to rely on experts in order to interpret their own world, particularly to provide them with a morality, especially since the morality they seemed to provide led do a horrific war and a materialist, consumerist society. Like the modernists they despised, fundamentalists recognized that the dominance of a new liberal, middle class modernism left a moral vacuum as it filled social life with the fruits of its sciences. But, these "fruits" had a price and both of these groups were unwilling to accept these changes uncritically. Because evolution was far more than a "theory" of nature, one should not be surprised that the reaction against evolution was not simply a reaction against a theory, even against science narrowly conceived. This reaction was a response to a new world that had sprung up over the last years of the nineteenth century and the early part of the twentieth, a world where questions of value were erased by a focus on "facts" which science claimed the exclusive right to provide.

PART TWO

"BIG SCIENCE" EDUCATION

Highlights of Argument-III

Period	Post-Antebellum 1865-1900	Progressive 1900-1917	Cold War 1945-1971	Globalization 1972-2003
Theory of US	Industrialization, growth of poor, create crisis for Protestant Gentry	Immigration, Migration and Urbanization inspire reform movements to "protect" US democracy	American nationalism and economy is strengthened through war with Communism; new social movements	
Instrumental Science	Science is professionalized; marked as technological and modern	Science becomes tool of political and educational reforms; sign of freedom/ democracy	Corporatized, elitist, and militarized science develops	
Schooling	Compulsory Schooling requires a modern curricula	Schooling is used to "Americanize" new immigrants and train future workers	Collapse of progressive education; schools must identify potential "geniuses"	
Science Education	Entry into US public education	Laboratory becomes important for doing "real" science; science for vocation	Key for success in Cold War; codification in *Sputnik* era curricula reforms; all must "understand" science	
Dominant Discourses of Evolution	Contest between selectionism and acquired inheritance	Evolutionary Synthesis: hegemony of gradualism and selection	Central Dogma: unidirectional transmission of genetic information	

Critical Science/Education	nature study; classical, liberal, and broad curriculum	Dewey's vision of education as art and as reflective experience	Multiculturalism diversifies schools and science; Lapp, Carson; context of science is recognized as vital	
Critical Science Education/Evolution	Nature Study as means to appreciate the nonhuman world; Lamarckian Socialism	Dewey's vision of science education as reflective experience; revival of Formalism in D'Arcy Thompson	relation of science and technology to society; work on mobility of genes (Mclintock)	
Educationalization of Science/ Scientization of Education	Science uses education to spread its influence	Education uses science in the form of testing, research and bureaucracy	Science uses education to communicate its importance for the fight against Communism	

Fifth Interlude-Big Science and the Logic of the Cold War

After the Second World War, American science opened a fundamentally new chapter in its existence. It had become integrated into the federal government, military, university and industry in far more complicated ways than before. American science became "Big Science." This interlude is intended to introduce the relationship between the Cold War and this new, large-scale, lucrative, corporatized science. Furthermore, it will detail how this variant of science pushed the anti-democratic, elitist vision of science further into the fore and refigured the majority of Americans as consumers of science/technology whose consumptive practices were a sign of their love of America.

The success of the atomic bomb in 1945 along with RADAR and other military technology led to the largest economic investment in research science the world had ever seen and the birth of "Big Science" or what Eisenhower later termed in his farewell address, the "military-industrial complex." Science was "big" in several senses. There were many individuals employed within it-from scientists, to contractors building equipment and laboratories, administrators, federal employees. It required large inputs of capital to build machines, apparatuses, laboratory complexes, pay salaries, fund non-for-profit "brain trusts" and similar centers and institutes. Science had a pivotal role in the policy making processes of the US government. That Big Science was able to grow in the ways that it did after the war was not simply an accident of history, but related to its ability to take advantage of two pivotal realties in post war life: the public, government and military's positive view of the possibilities of the products of science (again, particularly physics) as well as growing anti-Communist sentiments, the Cold War in general and the new, permanent war economy which sustained it. American science was again able to position itself as a practice of freedom and democracy, to be contrasted with the authoritarian forms of knowledge inquiry presumably practiced by the Soviet Union (the Lysenko case, as I will review later, became the paradigmatic illustration of the failures of Soviet science).

Two crucial figures in the transformation of the relationship between science and the State were Vannevar Bush and James B. Conant. Bush received his degree in Engineering in 1916 jointly from Harvard and MIT and was soon appointed a Professor of Engineering at MIT. While Bush was involved in some research (some regard his differential analyzer as a forerunner of the internet), he was best known in the pre-war years as president of MIT until 1939 when he became president of Carnegie in Washington. At MIT, Bush had become linked to both the federal government, appointed to the depression era's Science Advisory Board as well as the NACA (National Advisory Committee for Aeronautics) and to industry, establishing the Raytheon Corporation [which grew explosively in the 1950s due to defense contracts (Kevles, 1979)]. While in Washington at Carnegie, he furthered these connections by sitting on the boards of AT&T, Merck was well as several other organizations, institutions and universities. Politically, Bush was an anti-New Dealer, resenting the incursions of government on business, believing that they only ended up stifling economic growth and innovation. Bush was the consummate administrator and quickly became one of the four leading figures in American science policy along with Conant, Karl Compton and Frank Jewett. As the country moved closer to war, Bush decided that the technical nature of the war, that is, his seemingly correct supposition that the war would be one or lost based on technological superiority, led him to insist that the organization of weapons development not be left up to the "amateurs" in the military, but to experts. In 1940, he helped to convince Roosevelt to establish the NRDC (National Defense Research Committee), commanded by civilian scientists but linked to the appropriate military agencies. Bush was responsible for coordinating the relationships between the NDRC, military, Congress and the President.

In order to promote efficiency, Bush decided that the government would not do its own research but "contract out" research to the most capable research sites and universities in the country. He referred to this kind of decentralization as having a "pyramidal structure" (Geiger, 1993). In effect, this meant that contracts ended up going to the most elite universities and by 1941 the majority of contracts were assigned to about 20 universities with Harvard, MIT and The University of California acquiring over 30% of the total contracts between them (Kleinemann, 1995). Scientists would provide a service to the government for pay. The "contract" method was revolutionary and even Conant recognized this (Zachary, 1999).After the war, Bush's contract method would be institutionalized and reflect the way in which the federal government would to support scientific research until the present day.

Bush's notion as to the importance of the relationship between science, the military and government did have its own logic. According to G. Pascal Zachary (1999), one of Bush's more recent biographers, Bush recognized that although European fascism was reprehensible, it did allow for a more efficient relationship between the military and science. To counter this, democratic states would have to form similar types of tight relations between these associations, establishing the intellectual groundwork for the military-academic-industrial complex. In addition, it would have to further prioritize the role of the expert that had begun to be laid out during the progressive period. While acknowledging that this might set some limits on the democratic nature of governments, he considered this a sacrifice worth making (Zachary, 1999). If there were to be democracy, or at least a free-market of sorts, it would have to be commanded by experts.

In many ways, James Conant's career mirrored Bush's. Conant, a chemist and president of Harvard, was recruited by Bush to join the NDRC. Over the war years, Bush and Conant developed a partnership and a friendship wherein they were able to balance each other's personalities and, at times, act as foils for each other (Hershberg, 1993). With respect to most major science policy issues, they tended to agree. Unlike Bush, however, Conant was a New England liberal, comfortable with big government and committed to creating an educated public in the service of American democracy. Although Conant was instrumental in giving the green light to the Manhattan Project, from the get-go, he privately revealed he was more afraid of its success than failure, always hoping for an "unforeseen block" (Hershberg, 1993, p. 171). Like Bush and other policy makers, Conant believed that the United States should emerge from the war in charge of a new world order, replacing its old isolationist policies with expansionist ones. This led him to recommend leaving the British out of the details of the Manhattan Project because he felt that Washington should make decisions on nuclear policy alone. Eventually, like Bush, he recognized that the only way to keep the world safe from nuclear war was international regulation of nuclear power and, after the Soviets acquired the bomb, mutual disarmament.[1] This position, which led him to oppose the construction of the Hydrogen bomb in the 1950s, along with his vigorous support for Robert Oppenheimer after he was stripped of his security privileges due to his supposed communist leanings (though Conant did agree that professed communists should not be allowed to teach in American schools), eventually led him to fall out of favor in governmental circles and led to a new phase of his life as the US ambassador to the newly created West Germany, and later, as an analyst of American education (Conant, 1964).

One of Bush's leading contributions to post-war Science was the report he penned at the bequest of Roosevelt seeking to lay out how the federal government could continue its support of science after the war. The report, *Science, The Endless Frontier*, released in 1945, ultimately became one of the most important policy documents of twentieth century US science.[2] In *The Endless Frontier*, Bush articulated his view wherein the federal government would fund science while scientists themselves would decide how those moneys were spent. Before the war, foundations and industry funded much science (particularly physics); most of this research was directed at the development of specific

[1] For most of the war, however, Conant kept his growing fears about the dangers of nuclear weapons to himself, or at least, private. Conant supported the decision to use the bomb against Japan, even endorsing the conclusion that it should be dropped without warning on a heavily populated Japanese city and, for the rest of his life, never publicly expressed any regrets over his decision. It is unclear exactly what happened to Conant's liberalism, which would show up later in his educational writings, as he knew well that Japan was on the verge of defeat, although he always contended that he believed the bomb saved more lives than it destroyed. After the war, when some in the United States began to question whether the bomb should have been dropped, Conant was at the head of several campaigns to defend the decision to the American public.

[2] The same year, Bush also published *As We May Think*, where he predicted the paramount role technology, particularly information technology, would play in the future.

technologies, what Bush would call "applied." In contrast, Bush argued, the federal government must prioritize "basic" research, that is, research on the fundamental principles of physical and biological organization that "creates the funds from which the practical applications of knowledge must be drawn." It was only federal support for basic research that would ensure that US science retained its innovative nature. Furthermore, Bush was adamant about freeing science from "political interests," instead putting control firmly in the hands of leading scientists as only they could decide the merits of specific research. Of course, Bush's program had exactly the opposite effect, asserting the politics of a class of mostly white, middle-class men on the funding priorities and direction of American science.

The nature of post-war science is nicely illustrated by the political battles between Bush and Senator Harley Kilgore, a New Deal Democrat from West Virginia over the establishment of a National Science Foundation. Bush regarded the idea of a National Science Foundation as an extension of some of the organizations he presided over during the war which helped organize and fund wartime research science (i.e. The OSRD). Like its predecessors, Bush hoped this organization would prioritize basic research (which could later become the foundation for industrial research and technological development), direct funding to only the "best" research and schools, and remain firmly under the control of leading scientists, the vision Bush had already outlined in *Science, The Endless Frontier*. Kilgore, in contrast, regarded Bush's foundation as elitist and unresponsive to the people, who should be deciding the way the government spent money-not unlike the criticisms of Bryan earlier in the century. Thus, research had to prove itself to be economically and/or socially relevant. In addition, Kilgore criticized science for allowing the privatization of is discoveries (via patents)-allowing mostly private industry (and the universities they were affiliated with) to profit from scientific discoveries. He argued instead that the fruits of federally-sponsored science should be publicly owned. Finally, Kilgore criticized Bush's plan for not ensuring that federal funds be equitably distributed, rather than being awarded mostly to a handful of universities on the east and west coasts.

In the end, it was Bush's vision that prevailed. As Kleinman explains, Bush had powerful allies. Intense lobbying against the Kilgore bill by the National Association of Manufacturers [who accused the bill of trying to socialize industrial research (Kleinman, 1995, p. 89)] along with the military and fellow scientists (with the exception of the AASCW (American Association of Scientific Workers) who supported the democratization of science) virtually ensured the legislation would not pass. But, by the time the legislation passed in 1950 (after Truman had vetoed an earlier version), it no longer mattered that Bush's initial ideas were somewhat compromised as Big Science had already become what Bush wanted: scientist-driven, basic oriented and, with respect to funds, unevenly distributed.

Although the earlier war against fascism was important, key to the success of Big Science was the Cold War. The "war" against communism provided a means to increase defense spending, creating a permanent wartime economy which served mostly industry, and also facilitated one of the largest economic expansions in US history, opening most of the world to US economic control and companies. Finally, it often served as a means to manipulate voters and contain the growing influence of the left, particularly in postwar Europe and South East Asia (Kolko, 1968). Another important effect of the Cold War era was the dramatic rise in the selling of consumerism, including the selling of technology. Part of this was to push the women who had joined the workforce during the war back into their homes, lured by the latest wonders of kitchen technology, and to stimulate economic growth, creating what John Galbraith called "the affluent society." Americans were free, they were told, because they had the right to buy whatever products they wanted. Owning a home, television, or car became a marker of the kind of freedoms one could not achieve in a communist society. To produce this consumerist society, along with the economic expansion of the 1950s, government became more involved with industry, helping them both financially and politically, building roads, disposing wastes and launching satellites so as to help cut the costs associated with bringing new products to the market (Nasaw, 1979). Furthermore, the huge military budgets of the post-war years provided much of the income for consumers in the form of a vast credit system needed to support high sustained levels of consumption and therefore freedom (Aronowitz, 1974), while all along, the myth of a "missile gap" between the US and the USSR (the US always had a 2 to 1 advantage in nuclear missile delivery systems over the Soviets) kept a frightened US public behind these enormous expenses on defense.

The Cold War offered physicists many new funding and policy making opportunities and most were quick to take advantage of it. As the journal *Physics Today* proclaimed in 1950, "The Springtime of Big Physics has arrived" (cited in Kevles, 1979, p. 367). As the

Cold War progressed, the demand for physicists multiplied. With the outbreak of the conflict in Korea, federal investment in science passed the one billion-dollar mark. During these years, science became further entrenched into notions of American exceptionalism. While I traced some of this history in previous chapters, it was in the postwar period that science inserted itself into this mix on a permanent basis. What began with the dropping of the atomic bomb culminated with *Sputnik*. When, on October 4, 1957, Americans got news that the Russians had just successfully launched *Sputnik*, the first satellite to orbit the Earth, their sense of the US's superiority in science/technology was shattered. Strangely, while the Russians had made their intentions of launching *Sputnik* clear, when it finally happened, politicians, the press and ordinary Americans could hardly contain their shock. That this Russian success was so upsetting suggests that science was already tied to American nationalism, but the dismay over *Sputnik* and discussions over the "space race" which would now begin in full force indicate that this relation was now explicit. Therefore, in addition to further spending increases on science, the creation of new defense agencies to ensure the US's victory (NASA, ARPA), as well as the passage of the National Defense Act in 1958, success in science became a sign of the success of the American system itself, a sign that its unique liberal-democratic-system was the better one, as opposed to the repressive command-totalitarianism of Soviet socialism. If the US was to protect the American "way of life," it would have to prove its superiority on the plane of science, in particular, by "winning" the space race. A month later the Soviets launched *Sputnik II* and US science was humiliated once again.

As Geiger (1993) notes, Democrats took advantage of this national crisis--LBJ, then a senator, likened it to a second Pearl Harbor--and used it to oust the Republicans from power by proposing an ambitious space program as well as a science education program to return the US to its former glory. Many scientists also took advantage of this crisis arguing that the government needed to invest in secondary and college-level science if the US was to produce a new crop of high quality scientists. Although by 1957 there had already been much talk of a crisis in education, *Sputnik* offered policy makers a clear cut road to solve the problems besetting education-invest in science education. Eisenhower's new PSAC (President's Science Advisory Committee), headed by Killian, produced its influential *Education in the Age of Science* in 1959 which made the call for further spending on education. Some scientists argued that *Sputnik* was a result of a lack of commitment by the federal government to basic research and as a response, in the period from the mid-50s to the late 60s, national spending on basic research as a proportion of GNP nearly tripled (Geiger, 1993). The NAS along with the AAAS (American Association for the Advancement of Science) and the Alfred P. Sloan Foundation sponsored as symposium on "basic" research attended by some of the leading scientists and politicians in the country including Eisenhower. Next came the "Seaborg Report" in 1960, written by the chancellor of UC Berkeley which further tied an economic commitment to basic research to a commitment to America itself, or as he put it, an investment in our future. Not only did the federal government need to fund science, Seaborg argued, but support the entire system of science including creating an expansive fellowship program and developing the infrastructure of universities across the country. By the 1960s, scientists helped to propel themselves to an ever more important place in

American policy making and, after the election of JFK, found themselves in prominent places in the new administration.

This is not to suggest that all scientists were opportunists. By the mid-50s, some in the science community began to question whether the now taken-for-granted link between physics and defense was a good one. Shouldn't we justify physics, asked Samuel K. Allison in 1950, a physicist at the University of Chicago, "as a worthy intellectual activity of a world at peace?" (cited in Kevles, 1979, p. 369). After Eisenhower suspended Oppenheimer's security clearance in 1954 (mostly a result of his vocal opposition to the Hydrogen Bomb), the criticisms emanating both from inside and outside the scientific community became more vocal. Eisenhower's warning to Americans that science was becoming a part of a military-industrial complex, became a popular expression for these criticisms.

While these questions began to surface in the 1950s, the most influential of these criticisms came in the mid-60s in books like Ralph Lapp's *The New Priesthood* (1965) and H.L. Nieburg's *In the Name of Science* (1966) which spotlighted scientists increasing power in government and intimacy with big business. Scientists had become, as Lapp's title indicated, the new priests, increasingly breaking off "the conversation links between the layman and the laboratory" (1965, p. 1) as well as becoming, as Nieburg called them, "the new millionaires" (1966, p. 126). As Lapp noted, the disjunction between science and the public skyrocketed during the 1950s, with the outbreak of the conflict in Korea and the enormous amount of unaccountable government funding directed at scientific research. But Lapp, himself a nuclear scientist, continues, "Big science is not necessarily great science" (14), and, as control of science shifted to Washington, the exponential growth of administrators and bureaucracy threatened to extinguish science's "creative spark." Similarly, Lapp argued, the more money that is thrown at science departments in universities, the more they begin to think like businessmen and the less like scientists and academics. No longer trusting scientists to make decisions about what kinds of technology should or should not be produced and recognizing that science had no inner logic of its own which could be harnessed to answer these difficult questions, Lapp sought to open these techno-political questions to public debate, of which scientists remained only one interest group rather than a class of experts, Lapp's version of a populist science.

Chapter Five: Big Science Education for a Big Science

By the time the Eisenhower administration began to deal with the "crisis" in science education after *Sputnik*, US education had already been in "crisis" for nearly a decade. Following the excesses of the life-adjustment movement of the 1940s, conservative critics of education tried to explain what they regarded as the public schools systems failure to educate children. Harking back to the classic vs. modern curriculum debates of the late nineteenth century, critics of education argued that educators, influenced by progressive educational ideas, were so busy preparing children for life, that they were ignoring the basics of a classic liberal education. Thus, the new science curricula of the late 50s and early 60s evolved in this context. Furthermore, this context was profoundly shaped by the Cold War-just as success in science was to become a vindication of the American way of life, an expression of postwar nationalism, so too would be the case with education. If the US was competing with the Soviets with regard to education, after Sputnik, it was "clear" who was losing.

Thus, the new curricula would have to help bridge this gap. The new curricula would have to offer students a new version of science. As hard as science educators tried, they could no longer dismiss that Big Science had profoundly changed the nature of science. While curricula would still try to present science as the work of lone scientists using empiricist methods in their quest for truth, the new realities of science would shape these new curricula, even if not intentionally so on the part of its authors. The old version of science as nature study would live on only in the imagination of high school science textbooks. Once again, the educationalization of science would construct a portrait of science that helped in its legitimating capacity. This chapter will seek to identify exactly what kind of science education "prepared" kids for Big Science and the new world that supported it. By the late sixties, the effects of the new social movements would begin to be felt in schools. As I shall detail, critical variants of education, science and science education developed to articulate critiques of these structures. Unfortunately, by the end of the seventies retrenchment in government spending as well as a more conservative, pro-business thrust in education would spell the end of the effect of most of these critiques of instrumental science and schooling.

1. Another Crisis in Education

Perhaps something about the utilitarianism of the life adjustment movement of the 1940s-expressed in reports like *Education for ALL American Youth* (1944) and the "Prosser Resolution" (1945), where it was argued that the goal of schools was now to prepare youth for "citizenship," "vocation" and perhaps most disturbing of all "consumption"--simply went too far and spurned this latest self-described crisis. By 1949, according to the US Office of Education, some twenty percent of junior high schools and eleven percent of high schools explicitly took up these proposed curricular changes and many more schools were influenced by them (Ratvich, 1983). Not a moment had elapsed, quite literally, before the critics of progressive education made their assault. This new round began with Mortimer Adler's *And Madly Teach*, Hutchins *The Conflict in Education in a Democratic Society,* Woodring's *Let's Talk Sense About our Schools*, Albert Lynd's *Quackery in the Public Schools* and the classic defense of a liberal education, Arthur

Bestor's *Educational Wastelands*. The pages of US newspapers and magazines were filled with details and extensive discussion of this new crisis (Ratvich, 1983).

Bestor's (1953) work was probably the most nuanced, as well as the most sympathetic to some Progressives aims. It was also the closest of the works of this period identifying something like a critical education. For Bestor, it was not progressive education itself that was the problem, he himself had attended the Lincoln School, one of the most famous progressive schools in the country, but the anti-intellectualist variant that seemed to dominate contemporary pedagogy. Echoing Dewey, and what would later become Richard Hofstadter's take on progressive education as well, Bestor claimed that schools no longer bothered to teach children to think, which, he argued, should be their primary goal. Again echoing Dewey, Bestor insisted that US democracy could not sustain itself unless all its citizens received a rigorous liberal education. The life-adjustment movement was divorced from scholarship, history and the actual content of knowledge. He hoped his work would lead to reforms in schools themselves as well as the way teachers were trained. Specifically, he wanted teachers themselves to receive a better education in the subjects they taught. Bestor's influence could be seen in the reforms of science curricula of the late 50s in which practicing scientists were invited to rewrite curricula taking into account the latest developments in their fields. Unfortunately, as was the case with many critics of education, Bestor missed that public schools were working exactly as they were supposed to--reproducing the status-quo in American society. In this cynical sense, their "failures" were actually a marker of their success.

While Hutchins *The Conflict in Education* (1953) regarded the focus on life-adjustment in the late 1940s as a consequence of the anti-intellectualism of the anticommunist movements (again, like Bestor and Hofstadter), one can conceivably make the opposite case: that the curricular reforms and the reaction against the "life-adjustment" movement were part of a larger US nationalism which the Cold War helped to propel. The US was, after all, educating future scientists, politicians, businessmen and engineers on whose lap the triumph of capitalism/democracy over communism lay, or so the argument went. This is why, by the 1950s, many of the educational policy documents would focus on educating the "gifted." In reality, both are true, both the anti-intellectualism of the life adjustment movement and the humanism/traditionalism of the later reforms were shaped by anticommunist fervor, as it is simply impossible to divorce any of the educational movements after 1945 from the Cold War. By the end of the decade, as the US-Soviet space race took off, success in science was deemed crucial because it became tied to the success of liberal democracies themselves.

It is not hard to see this in the policy documents of this period. To start with, take the influential *Education for the Age of Big Science*, published in 1959 by Eisenhower's science advisory committee (PSAC). It presents its reforms as urgent in this particular period of time as, "the security of the Free World and the defense of human freedom are [the] inescapable responsibilities of the United States" (1). As this is the "age of science" and "the survival of our democratic institutions will be determined primarily by the excellence and appropriateness of our education patterns" (1), "a national effort is required to strengthen our scientific and technological efforts in all fields" (5) and cultivate a widespread dedication to and respect for learning… and a deep understanding between the public and the experts… [so that] he can understand the world of science in which he lives" (4, 6). While not everyone can become a scientist, "…a successful democratic society, in short, must have millions of well educated citizens who can comprehend what the specialists and the leaders are proposing, and who have a chance to judge these proposals wisely" (3). In these sentences, the primary relation of Big Science is articulated-expert to citizen, not unlike another dominant social relation of this period, industry to consumer. Littered throughout the report is the idea that people have differing "mental talents" who must receive an education that takes this into account. One finds many more instances of these two basic claims in the report. First, that the Cold War and the very survival of US democracy require a certain type of science education. And second, that science is a discourse where the layperson must learn to "comprehend" the expert. I will point to more instances of the importance of "comprehension" later.

The ways in which the Cold War dominated debates on science becomes even more apparent if one examines the ways in which it comes to dominate Bush's writing in the post war period. While *The Endless Frontier*, written at the close of the war, was clearly directed towards a nation at war, with many references to the "enemy," the enemy was fascism and an era of peace is on the way. Only a few years later, in his *Modern Arms and Free Men: A Discussion of the Role of Science in Preserving Democracy* (1949), Bush's tone and message has changed. First, there is an implication that the US is now engaged in an epic battle for the very survival of democracy (as opposed to simply "our national security" as in the prior report) and the enemy is no longer fascism, but the broader (and vaguer) "totalitarianism and dictatorship." Bush's alarmist opening lays out exactly what is at stake here.

> Is rigid totalitarianism to prevail, gradually drawing all free peoples into its orbit to form an enormous police state ruling the earth? Is democracy to spread, converting other to its tenets, until all men live in freedom? ... More immediate is the Soviet government to be stopped at its present boundaries, or turned back from its recent conquests? Are the free peoples of Europe to rise and regain their strength? ... The answer depends upon whether totalitarianism or democracy is the stronger in facing the complexities of modern existence, in truthfully interpreting the teachings of science, in ably utilizing the applications of science, in managing peace or conducting war... We have already fought with totalitarianism-the totalitarianism of the right-and have found part of the answer. Now we confront the totalitarianism of the left, and we had best examine it searchingly (193-4).

While Bush promises a "searching" examination, it should come as no surprise that he "discovers" that democracy is the stronger of the two systems. While communists professes to respect democracy they mistakenly believe that,

> our whole scheme, of elections and what not, is a sham, that the only real power resides in those who have money, who can buy the press or legislatures, who can determine the outcome of elections and thus rule. This country by definition is a capitalist country ruled by its wealthy class. Moreover, and here is the rub, they argue that we fear a revolution ourselves, and that hence we are convinced we must by all means stamp out the source of revolution, the Communist state, before it engulfs us... It sounds fantastic, but that is the thesis (196-7).

But, this "fantastic" communist thesis, like the Socialist state itself, is doomed to fail because of its rigidity and its inability to "tolerate heresy" or "allow its iron curtain to be fully penetrated" (200). Because the future of society depends on a form of science which requires an "open" mind (or as Karl Popper would put it, an "open society") and the free exchange of ideas, communist societies will inevitably collapse. Because, as Bush tells it, the essence of democracy is responsive to the will of the people, it allows for the kind of openness to and tolerance of diverse ideas that makes science flourish. At bottom, a successful democracy requires an educational system, says Bush, which encourages those who can "rise above this [regular] level" and contribute to society by becoming scientists. In other words, Bush is less concerned with creating, what he dismisses as "equality of educational exposure," as say Conant or the NEA might be, and more focused on protecting democracy by harnessing the talents of those who can excel at science.

By the mid-50s, a new round of reforms was initiated along with the other curricular reforms elicited by the perceived educational crisis of that time which focused more on the content of the courses. In his own summary of the history of biology curricula, Paul Hurd (1961), one of authors of the biology curriculum produced in the 1950s, argues that developments in science and the corresponding developments in technology and society itself necessitated a change in the manner in which student's were taught science. Science courses would have to keep up with the latest breakthroughs in science as well as educating students about the nature of science. Hurd doesn't have much to say about the Cold War, but even before *Sputnik*, the US was already involved in an arms race with the Soviets which required more scientists, as Bush had explained, and more "comprehension" of what scientists were doing.

In 1956, several leading physicists, led by Jerrold Zacharias, working with educators, created the Physical Science Study Committee (PSSC), funded by the NSF. By 1959 they had developed a new set of course materials in physics. The ACS (American Chemical Society) began working on its Chemical Bond Approach curricula in 1957. In 1955, the American Institute of Biological Sciences sponsored a committee on education and recruitment which was composed of scientists, school teachers, and school administrators and eventually became the Biological Sciences Curriculum Study (BSCS) which decided to produce a set of course materials which every student in biology would be expected to use. In 1960, three versions of the proposed curriculum were produced; (1) A "Green" version which centered around an ecological perspective; (2) a "Yellow" version with a genetic-evolutionary theme and, (3) a "Blue" version using a linear approach to explain different levels of biological organization. In the early 60s, many new biology textbooks were published guided by the curriculum and, by 1977, a national survey showed that 43% of surveyed schools districts were using the BSCS materials.

Now, if one follows the argument I am making one can expect two things about the curricula; first, that they prepare students for the reality of living in a society dominated by Big Science (along with Big Government and the Cold War) and second that they still leave the impression that, while one can "object" to scientific results if one is trained in science and speaks the language of science, politics and values are outside of science. They must teach students the role of the expert. In others words, if the "science" is "good," its results are "true" no matter what the political or otherwise nonscientific implications are. Furthermore, within the domain of science, it is the scientists themselves that determine what constitutes "good" science-exactly as Bush wanted it.

The BSCS curricula provide a nice illustration of this thesis. Take the "Yellow" version, *An inquiry into life* (1963). First, it is interesting to note that five out of the seven "preparers" [as opposed to authors of which there are over 50] of the text are university-based scientists and only two are high school biology teachers. The foreword lays out why the new curriculum is required,

> With each new generation our fund of scientific knowledge increases fivefold... In biology, the routines of teaching have drifted even farther from any approach that a scientist could recognize as an introduction to a science... We are profoundly convinced that the major fault in the teaching of biology... is that emphasis has been placed on authoritative content-facts, concepts, principles-instead of being placed on the investigative processes of science and the history of scientific ideas. [xvii]

No doubt, many teachers using the text have heard the call to focus on "process" before. And, the authors continue with a claim made many times before... "In order to live in a scientific-based civilization with some appreciation of the forces that are shaping the lives of modern citizens, what is especially needful is *an understanding of what science really is* [my emphasis]... a variety of ways of finding out verifiable information and building up concepts and principals that adequately explain what we know of nature's ways" (xviii). But, there is room to doubt whether this is what science "really" is. Maybe this is more the case with physics than biology, but the bottom line is that bulk of actual US scientific research when this was written was funded by the military, government and industry and was marginally concerned with "nature's ways." By this time, the old paradigm of science as "nature study" had long been replaced by a technocracy. It would, however continue to live on in high school textbooks. The authors argue that biological understanding is required for politics, in order to "...establish a basis for a better public understanding of the wise management of natural resources, of the biological hazards of nuclear agents in peace and war, and of the methods by which scientific information is achieved, as primary sources of national strength and well being in this new era of history" (xviii). One expects, naturally, that these factors-including the call to nationalism-only come after the "objective" part of science is complete, after one has, so to speak, gathered the facts. As is the case with all instrumental variants of science, the epistemological and socio-historical foundations of scientific thought are eclipsed.

It's crucial, at least at first, to assess the text within its own terms, especially as it does not meet even these, before we look at how it fails to describe "how science really is." The question of nuclear weapons probably won't come up, as that would likely belong in a physics text, but what about "the wise management of natural resources"? Clearly, this has some biological implications. How well do the authors explain "how science really works" with respect to this? These questions are taken up in a chapter entitled "Man and the Balance of Nature" which, in a preliminary description warns us that, as opposed to "primitive" man, who lived in balance with nature,[1] "civilized" man,

> has approached nature with an arrogance that could feasibly be his own undoing. By poor agricultural practices he has destroyed vast areas of productive soil; he has devastated forests, only to find his water supply diminished and his soil supply eroding; he has fouled up the rivers and streams, thereby making the water unsuitable to his needs. But today is beginning to behave as he must-as a living creature who depends on other life for his own existence (xv-xvi).

While there is not much to object to in this dire, but mostly correct analysis, one is left pondering two questions. First, who exactly is the "man" who did this and who continues to do this, though is, in some cases, cleaning up his act? And second, is there a relationship between this "arrogant" relation to nature and the project of science itself, and if so, what is it? To answer these questions let's turn to the chapter itself, which is

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[1] If one accepts that natural selection is the primary mechanism for evolutionary change, which these authors obviously do, what exactly is this "balance" with nature that the "primitive man" lives in? In other words, doesn't selection at times involve a "lack of balance" or, in other terms, the inability to adapt? It is always fascinating to me to see how early nineteenth century romantic notions of nature—balanced, whole, righteous—are combined with neo-Darwinian ones—struggle, competition, violence.

notably one of the shortest chapters in the book and also at the very end of the text. Given the rigor of the curriculum, it is a point that many biology classes will likely never reach.[2]

The chapter in the 1963 edition begins with the idea that all creatures, including humans, must live in balance with nature. At times, in a rush to eliminate predators, "man" introduces "stress into the environment" (707) by "simplifying the food web, removing cross-connections that might give it stability... some of [which]... can be disastrous to his plans (707). While "no other species has triumphed over predators and infectious diseases... [used] deserts to produce crops through irrigation..." (707), prolonging life and interfering with natural selection thereby changing "the nature of the genetic balance in his own species" (708), all is not well for all "mankind." Certain areas of the world do not have enough nutritious food. While in certain parts of the worlds (re: the West) the need for food (and the mechanization of agriculture it requires) has now, through scientific advance, utilized knowledge so that soil erosion is reduced and its supply of organic and inorganic compounds is retained, in other more desperate pats of the world (re: the "third" world), the demand for food is so urgent that "scientific methods cannot be followed" (711). "How can people sell part of the crop to buy fertilizers," the authors of the text go on to ask, "when every grain of crop is needed to keep their children from starving?" (711). This fact, along with a depleting fresh water supply and a growing world population (again, mostly in the "third" world), leads the authors to conclude that "population growth has become one of the most serious problems for our species" (712).

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2 As an aside, the version I am reading was published by Harcourt, Brace and World in 1963, a few years after the original curriculum was written, and one can expect this focus (however brief) on ecology is a consequence of a growing environmental movement. In the original 1960 version there is no chapter devoted to ecology at all, only one on "Selected Topics in Biology."

The authors continue, "Every reader of this book belongs to a generation that must help solve this problem" (712).

Before we consider whether the text offers any tools for the "reader" to help solve this problem, let's examine one more section of the chapter detailing the "Uses and abuses of our natural resources." The authors advise readers that while part of technological advance involves making use of substances that either did not exist or humans did not understand how to use them in beneficial ways (i.e. detergents, alcohol, paper, insecticide), they end up ignoring the natural resources already present on the planet and "press them progressively toward extinction" (715). According to the text, many animals are particularly vulnerable, though efforts are now being made to save them. Often, this move toward extinction is the fault of "man" who "leave[s] them too little room" by aiming "at greater efficiency in food production" (717) and spraying plants with chemicals and pesticides. While the authors recognize that, "few people would criticize man, or any other animal, for defending his food supply," they warn "is it right to exterminate the neutral and helpful species by poisoning or crowding?" (717). Even if one does destroy "pests" and such, chances are they themselves will evolve and become neutral to technology. Finally, the authors conclude it is in our best interest to protect them as "they serve us, far more completely than we know today, in maintaining a dynamic balance throughout the natural world. This balance is the sole stabilizing feature of the environment in which mankind continues to evolve" (719).

The neo-Malthusian argument about overpopulation, while buttressed by an NAS study, is hardly new.[3] And yet, the authors make some odd assumptions and leave out much that, even from the vantage point of the early sixties, hardly seem to describe science "as it really is." First, the authors begin with an interesting assumption, it is not Western technology that puts the environment in danger, for the most part, but the third world's lack of technology and poor farming practices. What makes this all the more stranger, is, as the authors say in the introduction, it is man's "arrogance" that is, in part, responsible for this damage; thus we are left to wonder if it is the arrogance of the West and their willingness to uncritically use all their technological advances wherever they see fit that is the problem, or is it the "arrogance" (or "backwardness") of non-Western countries who seem to refuse to use the modern/Western advances in science in their farming practices and are thus partly to blame for ruining the "balance of nature?" Oddly, an explanation of the nature of this "arrogance" is never offered in the actual chapter.

It is too easy to make explicit some of the racist and naïve assumptions with respect to technology in the textbook, a product of its times, but I will now turn to two more basic questions: who is the "man" that is doing the destroying? And what is the relationship between this destruction and science? First, it does appear that-contrary to the claim in the introduction-it is "uncivilized" man that is doing the damage to the earth and "civilized" man, that is, technologically savvy man, that has the tools to save it. When "uncivilized" man does damage-a factor of his "arrogance" or, at more sensitive moments in the text, "desperation"-it is mostly through *not* using the developments of science

[3] Let's not forget there are still many scientists who believe that "overpopulation," particularly in the "third world" is one of the world's pressing environmental-political problems. The argument always forgets that it is the rich countries that consume the bulk of the planet's resources.

rather than using them. If only the technological developments of science were more utilized and widespread, the authors imply, at least for the most part, the environment would not be in quite so much danger. Thus, the answer to our second question is clear: science/technology, when used properly (and not to "destabilize the balance of nature") can prevent this "destruction" and by ignoring the results of modern science humans are only speeding up the destruction of their natural resources. Finally, while the text holds "man" responsible for this environmental damage (mostly "man" in the third world) it doesn't say which "man" (or "woman," for that matter)? Who is invested in certain kinds of farming practices, water practices and using natural resources for their own ends? Is it all humans? Is it industry or governments who use resources in this way? While this text was written before the idea that environmental pollutants were a grave danger to the health of the planet became widely accepted, are their any specific industries or people's that are directly involved in destroying the environment?

Also, missing from the chapter is "what science really is?" Other than a few terms out of botany/natural ecology to describe the degradation of the environment, there is not much offered in the ways in which science is actually intervening in these problems (or even studying them) with the exception of trying to spread its mechanized food production practices and ideas around letting the soil remain "fallow" for a year--which other cultures had been doing since the beginnings of agrarian societies and had been replaced the continuous soil use by Europeans towards the end of the Middle Ages. Now, we know better. It is the mechanization of agricultural along with other "advances" in science that have wrought far more environmental degradation of the planet rather than the other way around. As many critics have pointed out, it is not the refusal of science, but science itself, a science that believes that it can control nature as it sees fit, that carries with it the kind of "arrogance" the authors of the text refer too.

Again, it is far too easy to criticize the ecology of 1963 writing from the vantage point of 2003 where some science, but mostly a scientifically and nonscientifically inclined environmental movement, has uncovered far more dangers to the environment than poor farming and water practices, overpopulation and insecticides. However, the authors of the curriculum do make reference to Rachel Carson's *Silent Spring* (1962), the seminal work of 1960s environmentalism, which offers a much more devastating and politicized picture of damage to the environment than these authors do. Carson's opening words still have resonance today.

> Only within the moment of time represented by the present century has one species-man-acquired significant power to alter the nature of his world... this power has not only increased to one of disturbing magnitude but it has changed in character. The most alarming of all man's assaults upon the environment is the contamination of air, earth, rivers, and sea with dangerous and even lethal materials. The pollution is for the most part irrecoverable... In this now universal contamination of the environment, chemicals are the sinister and little recognized partners of radiation in changing the very nature of the world-the very nature of its life (Carson, 1962, p. 5-6).

Carson's strong condemnation of Western technoscience is followed by a detailed accounting of the chemicals-insecticides, pollutants, fertilizers-widely used to degrade the environment. But, unlike the BCSC text she goes much further and lets the reader know who is doing the polluting. She offers examples where the culprits are corporations-the chemical industry in particular--farmers and even the US government. Why, asks Carson, are these forces allowed to wreck havoc on the ecological stability of the planet? Again, the answer is simple yet not surprisingly missing from the BCSC curriculum. All of this is in the service of the profits of the chemical industry, supported by a government that puts the needs of corporations over the environment. All the while, the chemical industry, state and federal government agencies, even scientists themselves deny what is happening all around them. Unfortunately, Carson tells us, much of science cannot help as "this is an era of specialists, each of whom sees his own problem and is unaware of or intolerant of the larger frame into which it fits" (13) [4] and this science which seeks control of nature is "born of the Neanderthal age of biology and philosophy... The concepts and practices... for the most part date from that Stone Age of science. It is alarming that so primitive a science has armed itself with the most modern and terrible weapons...[and has] turned them against the earth" (297). While Carson recognizes that a better science can help stop this, it is a fundamentally different kind of science, much more concerned with understanding nature in its own terms and its interrelations with humans rather than harnessing nature for our own ends. It is, in other terms, a science invested with a politics, a critical science.

By the 1968 version of the revised "Blue" book, the section on the environment does acknowledge that waste materials from industrial plants, automobiles, agricultural areas and city sewers can produce health hazards and upset the ecological balance of natural communities. Further it recognizes that the effects of these pollutants can be studied "scientifically" by identifying the presence of certain bacteria or other organisms in an

[4] Sadder still, during these years, the US government generously funded research on environmental hazards. Today, much of this research is done by the chemical, oil and agro-business companies, in other words, those responsible for the pollution in the first place.

ecosystem, but even this revised "eco-friendly" edition misses much about "real" science. Again, the reader is warned that this "problem must be solved in your lifetime" (740), but other than vague notions of prevention, it is not clear how, especially given that the culprits of this damage are simply identified as "industries" and "communities." At times, the authors identify pollution in specific areas (i.e. The Conestoga Basin, coal mining processes in Eastern States), but while this might be a bit more specific than "man," its not much more so and never tells us who we (the reader) need to stop in order to affect change, other than that we must help "man" realize his resources are not inexhaustible and that we can help make change by determining policy, paying taxes and passing laws. Other than paying taxes, which most readers of the text will eventually do-though it is hard to see how this brings about environmental change-it is unlikely that most readers will be involved in "determining policy" or "making laws," except perhaps in the popularized and naïve version of the workings of US democracy-that through a citizen's vote and elected representatives s/he can make changes in policy and law. Second, and perhaps most importantly, what the text misses is that, quantitatively and economically speaking, much more of "scientific" research is devoted to producing these pollutants rather than studying the effects of them or how to rid our environment of them. Was it not the science of chemical companies that produced these pollutants in the first place?

The two things that are most clear in this chapter are a naïve faith in the progressive nature of the results of science as well as-contra its explicit mission-very little mention of science "as it really it." Each of these, I would argue, complement the promotion of a particular kind of scientific subject who is supposed to accept the results (and large funding) of Big Science uncritically, celebrate its technological advances and passively consume the knowledge produced by "experts." Furthermore, it is designed to produce a fictional vision of science that looks nothing like the real thing. Just to prove this example from ecology is not a fluke, let's look closely at one more variant of the new science curricula produced in this period, especially as it details "how science really works." Another version of the high school BSCS curriculum dealing with genetics simplifies science--or better yet, produces the fiction of empirical practice--even further. When asking whether "crabbiness" and other personality characteristics differ according to gender and are genetically predetermined the authors simply say, "we can answer the question if we can find out if the genes and chromosomes of girls are different from those of boys?" (1970, 251). The authors give the impression that the solution is simply a matter of learning how to "look" at chromosomes properly. While I will deal with some of the misconceptions of this genetic paradigm in the next chapter, two things are worth noting. First, Watson and Crick's DNA hypothesis, the depiction of our "genetic code," was generated through theorizing and speculating rather than "seeing." In fact, much of contemporary science (particularly physics, but even molecular biology) is far more "theoretical" than it is "empirical," at least in any traditional sense of the term. Second, while the whole point of the BCSC reforms was to allow citizens to know enough science so that they can participate in US techno-scientific policy making, the reader is never taught much about how to "look" at chromosomes. Presumably, the scientist will figure that all out, and citizens just need sit back and wait for his/her pronouncements.

One final example, the Chemistry text (1963) resulting from the CEMS Study, also dedicated to creating a scientifically educated citizenry, offers a section on nuclear energy, fission and fussion. While the section offers several formulas on fission reactions, there is barely a word on nuclear weapons except that when the reaction takes place at high degrees it can have "destructive" consequences. This is in 1963, when the world was at the closest it had ever been to nuclear holocaust. Needless to say, there is no mention of why the US starting splitting nuclei in the first place, except a presumption which pervades all these texts, that science is simply interesting in studying nature as it is. Again, there is no pathway for the nonscientist offered except to wait until scientists find a "less destructive" version of this reaction so that it could "be used as an energy source" (419).

These few examples indicate much about the purpose of science education in this period. It is worth dwelling on them as they have profoundly shaped science curricula to this day. It is hardly to "educate" citizenry. Most students will end up with only a shallow knowledge of some scientific vocabulary and the hope that science will soon "discover" what it needs to and a lucky few will get to become working scientists. For the rest of the students, they are left with a version of science that fetishizes observation and ignores the tremendous input of capital--in the forms of people, machinery and materials--required to make science work. Can we honestly say that these texts describe science as it really is? But, one might object, since it is impossible to do "real" science in schools, the curricula are trying to inculcate the ability for students to "think" and "act" like a scientist. But, even this is not true. "Real" scientists spend as much time writing grants-and therefore thinking of how to convince funders a particular project is in their interest-or tinkering with machinery and chemicals than they do "seeing" nature. If this is not the point of these texts at all, as I am arguing, what is their purpose? It is at this point one must recognize what is at stake in producing this particular form of scientifically literate (a term that will come into vogue only later) citizenry? Its mission is to create a citizenry ready to accept and value Big Science, ready to trust the "results" of science and willing to accept that the success of US democracy and its ability to prevail over Communism requires victories in science and education. With respect to these, it requires more and better technology as well as both a "sorting" mechanism to identify the "gifted,"-basic to the schooling paradigm--and a relatively passive citizenry ready to accept that the idealized version of US democracy is the one that actually exists in practice. If, every so often, this is not the case (as in the McCarthy years), it is through "taxes, policy and laws" that changes must be made. Bush could not have dreamed of a more appropriate science education. Collective action by the people including control over scientific policy is not simply "communist," it is anti-democratic.

2. The Explosion and the "Revolt" Against Science

In Daniel Kevles (1979) influential survey of the history of the US physics community, he refers to the decade of the sixties as a time of "revolt" against science. While there is some truth in this, the "revolution" was far more shallow than substantive, explaining why science was able to "recover" from the revolt so prominently by the eighties. This is not to deny that the sixties were an explosive decade. Between the civil rights/Black Power, anti-war and environmental movements as well as the later revival of feminism and other movements for social justice, much of US society was shaken to its core. These critiques of US society affected science as well, both with respect to the question of where and for what science got funding as well as a leftist shift among scientists themselves. By the seventies some of these changes naturally affected science in schools as well. Yet, as important as these movements were, they tended to miss the more basic ways science functioned in US society. It was less a question of where science got money (though this remains an important question), and more a problem of how science is used to rationalize US society and even subtend popular democracy, allowing it to use success in science as a marker of its liberal and democratic nature. In other words, it wasn't simply the way science was operating that was the problem, but science itself.

Although the decade of the sixties opened with growing criticisms of Big Science and Eisenhower's warning as to the dangers of the military-industrial complex, when the Kennedy's came to Washington-bringing with them a litany of scientist and social scientist advisors-scientists retained key positions in US policy formation. As the Kennedy's re-ignited the Cold War-perhaps to secure their "anticommunist" credentials--through confrontations with the Soviets over Berlin, Cuba and, Southeast Asia, as well as secured the importance of science by promising to put a man on the moon by decade's end, science re-communicated its importance in US society. The United States continued to produce enough nuclear weapons to destroy the major cities of the world a hundred times over (Kevles, 1979, p.398). While members of Kennedy's science commission were among the first to question the possibility of success in Vietnam, they, like many of his other policy advisers, kept their doubts to themselves. Their most lasting contribution, particularly the physicists on the commission, was to push the administration to sign a nuclear test ban treaty.

In the US, between 1960 and 1970, the number of university-age students jumped by over 50% and by 1970, for the first time, over half of high school graduates attended college. This educated youth helped to revitalize the left in America. As the university grew more important in its role as the primary "knowledge" producer of postwar America, it was inevitable that some of the most radical critics of the sixties generation would emerge from this environment. One of the 60s counterculture's many spokespersons, historian Theodore Roszak--reacting against the president of the University of California, Clark Kerr's conception of a multiversity, dedicated to both learning and service for the state--described the funding requests for new high energy particle accelerators as an example of "major scientific talent taking advantage of the public gullibility" and a handmaiden to the "aggressive... industrialization of the world [,]... to the scientists universe as the only sane reality[,]... [to] an unavoidable technocratic elitism" (cited in Kevles, 1979, p.401). Another critic of the high energy program, physicist Alvin Weinberg, argued that the focus of the research should shift to cheaper energy sources and environmental problems. Weinberg's program was killed due to the fiscal crises of the early seventies (Kevles, 1979). With the war in Vietnam escalating, a growing public awareness of the sheer vastness of the relations between the military, industry and science led to a whole new round of scrutiny over the activities of Big Science.

The most important charge of these criticisms of science was the idea that all people and not only scientists, had the right to decide scientific policy, and with respect to the government, funding priorities. The "revolt" against science led to a more populist oriented science policy, as envisioned by Harry Kilgore after the war in his battles with Bush. Contra Kevles though, the days of Big Science were hardly numbered as university-based science would increasingly look toward private sources of funding in order to avoid the instability of federal funding and their consequent dependence on popular support and Congress. Many of these changes in science, although moderately "populist," were not very substantive. Ironically, they could have been, as in the philosophy of science, the sense of certainty science had inherited from the Enlightenment began to be called into question.

Whether it was Quine's (1961) critique of the analytic/synthetic division of scientific statements, Norwood's Hanson's (1958) doubts as to the possibility of theory-free observations, or most influentially, Thomas Kuhn's (1962) writing on the paradigmatic nature of science (and his "incommesurability thesis"), the philosophy of science finally caught up with the destabilization of certainty associated with the quantum paradigm earlier in the century. However, outside the humanities, this work had little effect on the authority accorded to scientific knowledge, especially with respect to practicing scientists and the State. While this work, particularly Kuhn's, which had introduced the idea that scientific "truths" were relative to particular contexts or paradigms appeared to suggest that popular forms of knowledge production were just as legitimate as scientific ones, few critics of science in this period took this up (though this would be taken up in the US in the eighties by critics identified with "postmodernism").[5] Instead of asking why science, with its particular limitations, had acquired the kind of power it did in US society, critics generally argued for a better science in terms of who funded it, who staffed it, and what it studied, a science more accountable to the "people." To be sure, there were some radicals in this period who rejected Big Science altogether, but the question of the role science played in social life was usually not never a central question--with the exception of social critics like C. Wright Mills, Herbert Marcuse and Alvin Gouldner.

The sixties and early seventies also witnessed some profound changes in US public schools. While the sixties opened with a newly sympathetic read of progressives by Lawrence Cremin (1961), by the end of the decade, progressivism was regarded by some radical critics as part of a larger project by the schools to maintain the status quo. In books like Paul Goodman's *Compulsory Mis-Education* (1964), Charles Silberman's *Crisis in the Classroom* (1970) and David Nasaw's *Schooled to Order* (1974), the argument was made schools were agents of social stratification and control. Other books, like Ivan Illich's (1970) *Deschooling Society* inspired the "open" and alternative schooling movements of the early 1970s, reinvigorating some of the progressive's basic ideals. Although many read Illich's work simply as a critique of schooling, it was far broader in scope, a Weberian critique of the bureaucratic nature of Western society and its consequences for social life. Clearly influenced, as were many others, by Marcuse's *One-Dimensional Man*, Illich writes,

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[5] Steven Fuller (2000) is correct when he points to the conservative consequences of "Kuhnification." Even Kuhn himself would later recant some of the more relativistic implications of his work as tribute to his Popperian roots.

> I want to raise the question of... man's nature and the nature of modern institutions... To do so, I have chosen the school as my paradigm, and I therefore deal only indirectly with other bureaucratic agencies of the corporate state... My analysis of the hidden curriculum of school should make it clear that public education would profit from the deschooling of society, just as family life, politics, security, faith and communication would profit from an analogous process (2).

The Marxist revival in the academy produced a host of works-Brazilian educator, Paulo Freire's classic (1973) *Pedagogy of the Oppressed*, Bowles and Gintis' *Schooling in Capitalist America* (1976) and Paul Willis's (1981) *Learning to Labour*-which identified public schools as sites for the training of a docile future working class. The same was the case with the resurgence of feminism in the academy which pointed to the way in which schools reproduced patriarchal-dominated, gendered subjectivies (Walkerdine, 1998). By the early eighties, many of these strands coalesced into a movement which became known as critical pedagogy, a movement which sought to extend this critique of schooling to tracking (Bourdieu and Passeron, 1977), educational practice (Apple, 1982; Apple and Weiss, 1983), dropouts (Fine, 1991), language (Bisseret, 1979), curriculum (Giroux, 1981) and educational reform (Popkewitz, 1982).

By the late sixties competition with the Soviets appeared to be less important to educational reformers than redressing issues of racial injustice. Especially after the Supreme Court's rejection of "separate but equal" in the collective of cases known as *Brown v. Board of Education*, a host of studies by social scientists on the "cultural deprivation" of minority youth (e.g. Riesman's *The Culturally Deprived Child*, Michael Harrington's *The Other America*--much in the spirit of "helping" minorities as in the infamous Moynihan report) and a litany of books examined the relationship between race and education. One of the best of this genre, Jonathan Kozol's *Death at an Early Age*

(1967), documented the terrible physical conditions and racism minority children had to endure in public schools at the hands of white teachers and an overextended bureaucracy. Although over ten years separate the *Brown* decision from Kozol's study, he eloquently demonstrates the continual de-facto segregation of Boston public schools. Some advocates for minority children in public schools argued that public schools imposed alien "middle-class values" on non-white children. Critics like Kenneth Clark responded to these "cultural deprivation" theories (the same Clark whose research helped support the original *Brown* decision) by arguing that, whether the "problem" with black kids lay in their genes or the environment, the problem was always with black kids. The problem, Clark argued, was with the low expectations of white teachers, an argument which added further fuel to those advocating local control of schools as in the turbulent battle over the Ocean Hill-Brownsville community-run school in Brooklyn, NY.

With respect to science education, three major movements of reform emanated from this period. The first developed the notion of a "scientifically literate" citizenry and related it to the idea of a more populist-oriented science. Paul Hurd, one of the authors of the BSCS curricula, was one of the first to take up the term "scientific literacy" in a 1958 article entitled "Scientific Literacy: Its meaning for American Schools" (DeBoer, 1991). The term gained further prominence when the NSTA identified scientific literacy as it primary goal for science education in the 1970s. Curricular winds had shifted quite rapidly in science. No longer was the focus to be on the structure and content of scientific disciplines themselves, but instead on the ways in which science could be utilized by the average citizen (DeBoer, 1991). In addition to its reaffirmation of the populism of the

Progressive movement, the shift also likely reflected the reduced role scientists played in curriculum development, in contrast to the previous decade. In this sense, Kevles was right, not about a "revolt" against science, but against scientists. Still, these changes did not alter the particular relationship between "expert" and "citizen" articulated by Big Science. While citizens had a right to demand that government-funded science be responsive to their needs, in the end, it was still the scientists who decided what good science was, and thus indirectly, what can be studied.

In 1971, James Gallagher introduced the STS theme in an article entitled "A Broader Base for Science Teaching." As he put it, "...for future citizens in a democracy, understanding the interrelations of science, technology and society may be as important as understanding the concepts and processes of science" (cited in Deboer, 1991, p.178). Eleven years later, in 1982, the NSTA adopted a position statement entitled "Science-Technology-Society: Science Education for the 1980s" and STS themes, which were frequently connected to scientific literacy themes, abounded in the literature on science education (DeBoer, 1991). Paradoxically, some of this was due to the influence of Kuhn several decades after he published *The Structure of Scientific Revolutions.* According to STS, the context in which scientific knowledge was generated did count after all, but as was the case with Kuhn, these factors were still "external" to science itself. STS educators often focused on the humanistic, ethical and environmental aspects of science education. Topics like lead poisoning, energy conservation, pollution and nuclear weapons slowly began to occupy more space in science texts, but the students were still taught that, ultimately, one looked to the facts gathered by science for solutions (DeBoer, 1991). This meant that the value-neutrality and thus legitimacy of scientific knowledge could be preserved while science educators appeared to be responding to some of the critical issues raised by the sixties generation. By the late eighties the STS theme was under attack for not conveying the structural integrity of science and ignoring the "basics." The new science standards of the nineties would attempt to bring together, once again, content and process, as well as including a bit of context.

The third movement in science education related to the sixties was the attempt to focus on minority scientists in an attempt to diversify science in schools. Needless to say this did little to alter the basic understanding of science. A brief illustration will suffice. Although this text is of recent origin, the problems with this attempt at equity are clear. *Science in the Multicultural Classroom* (Barba, 1995) is a text intended for teachers so that they can offer a science education fit for "diverse" learners and "culturally different" children. The author tells us of the low number of minorities choosing careers in the sciences, and presumably, hopes that courses like this might change this trend--though the author acknowledges other socioeconomic, racial and gender barriers to careers in science. By teaching science as "a way of knowing" (6) rather than as a "body of facts" (6) the author hopes, as many have before her, that students will be turned on to science. With the exception of a brief characterization of much science as "Eurocentric" and "Androcentric" the author's depiction of science reads a lot like one which we might find in a "traditional" science text. Science is a way of knowing that seeks simple, testable solutions to real life problems and is both a relatively unified body of knowledge as well as a method for knowing. The author even goes as far as saying that scientific knowledge is itself value-free, but it is only in its application that moral dilemmas arise. In fact, much of the textbook reads exactly like any other science textbook.

How does it plan to excite "diverse" learners? The text offers several solutions including a relatively small subsection on minority under-representation in science. It seeks to replace the "deficit" model of minority failure in science (minorities are simply not good at science) with a multicultural one (the diversity of minority students and their particular "learning style" adds to the quality of science). It suggests making science classes more "user-friendly," and finally, by highlighting the contributions of females and minorities to science, even when those discoveries where credited to white males in more traditional accounts. There is even a table containing a list of over a hundred "diverse" scientists (64-67). Although the author offers many lively tales of scientific discoveries in diverse contexts, even alternate methods for knowing (e.g. an oral tradition, group discoveries), the fundamentals of science remain within the "Eurocentric" tradition the author rejects. Unfortunately, the new "multicultural" science did little to question the nature of science itself. Like much pedagogy which calls itself "multicultural," it simply believes that by adding on "diverse" perspectives, one has rooted out "Eurocentrism." Usually the "minority" perspective is lifted out of time and place and becomes as singular and universal as the traditional one. One of the great critics of Eurocentrism, Frantz Fanon, would insist that scientific knowledge is connected with race in a much more complex way. Science, European civilization itself, is built on the "backs" of people of color; literally, as it was slave labor and the resources extracted from colonialization that produced the kind of wealth necessary for science to grow and, symbolically, by designating them as peoples of "unreason," irrationality was expelled from the European mind and culture and located on a colored Other. In one of the most powerful critiques of "Eurocentrism" ever written, Fanon explains,

> each individual has to charge the blame for his baser drives, his impulses, to the account of an evil genius, which is that of the culture to which he belongs (we have seen that this is the Negro). This collective guilt is borne by what is conventionally called the scapegoat. *Now the scapegoat for white society-which is based on myths of progress, civilization, liberalism, education, enlightenment, refinement-will be precisely the force that opposes the triumph and expansion of these myths. This brutal opposing force is supplied by the Negro* (Fanon, 1967, p.194).

The same argument can also be made in the case of other "irrational" others--women, children, the insane, criminals, etc. The point is that the legacy of the sixties in science education reform, although did articulate a more critical variant of pedagogy, did not fundamentally identify anything about the nature of science, about its necessity as a means to perpetuate the myth that the US is both a "liberal" and "democratic" society, and that with respect to the Other, s/he has been excluded from science, not by historical accident, but as a fundamental requirement for producing value-free, rational knowledge. The expulsion of these peoples from Reason, like the expulsion of Nature from Reason, the foundational premise of Enlightenment science, is what gives "Man" the capacity to Reason and fill "his" institutions of science with certainty.

The most lasting legacy of the sixties was to demonstrate the intimate relationship between the projects of value-neutrality, colonialism and patriarchy. Unfortunately in science and science education, the new populist spirit of these years was reduced mostly to moves toward increasing minority representation in science. Because reparation was limited to "representation," it would not allow these new perspectives to change the nature of science nor would it allow any critical questions around why science was so important to US society in the first place. The only way to fundamentally change science, I argue, is to divest it of its authority. One must recognize it for what it really is, a useful, sensible, and in its best forms, skeptical, but imperfect way of engaging the world.

Chapter Six: How to Create "The" Story about the Origins of Life

As the title of this chapter indicates, my focus will now return to the history of evolutionary theory, specifically how a particular version of Darwinism, which was then translated into an even more particulate version of genetics, became the only legitimate way to describe the origin of species. When I last left Darwin, in a previous chapter, I found first, that Darwin created a version of evolutionary theory out of ideas which preceded him and which were digestible to leading scientists of his age; and second, that many in the scientific community found the idea of evolution completely compatible with the idea that God had created life. Also, as I suggested in that chapter, Darwinism was hardly the only version of evolution around and by the end of the nineteenth century, many thought Darwinism itself (as opposed to the broader idea of evolution) was dead.

Darwinism's place in the pantheon of biology changed (a) at the turn of the century, by the rediscovery of Gregory Mendel's paper on inheritance, (b) over the decades from 1930 to 1960, becoming the only game in town with the subsequent developments of the "modern synthesis" (the union of genetics and evolution) and (c) the "central dogma" (the uni-directional model of genetic transmission). Ironically, although Darwinism was widely accepted by the 1950s, the more successful the results of molecular biology, the more "evolution" became a background assumption rather that a lively, glamorous, well-funded research paradigm. By the 1970s, this (geneticized) version of Darwinism would be extended (once again) to all social relations in "sociobiology" as these relations were reduced to the needs of our "selfish" genes. As the dominant versions of evolutionary thought fetishized genes more and more, it received a final show of support from (coda) the growing bio-tech industries, which could now prove the verity of this version of evolution/genetics by demonstrating its capacity to transform human nature. This chapter will follow this narrative, with each letter representing one section, on two levels, both in developments of the theory of evolution itself and on the level of the consequent changes in high school biology textbooks which help to see how particular versions of evolution were consolidated, linked together, and essentially became dogma.

What I hope to demonstrate is that contemporaneous understandings of Darwinism and selectionism were based, in part, on responses to certain historical and political conditions that shaped evolutionary theory and science in general over the course of the twentieth century. As is the case with most controversies in science, the politics of particular directions taken by science are obscured by references to the so-called evidence. The further one gets from the controversy, the easier it is to write such revisionist accounts. In the case of natural selection, the now-dominant mode of explaining evolutionary change, two political considerations were key: (a) assuring that evolutionary change did not occur through human intervention but was, in essence, random, and (b) turning selectionism from a science based mostly on historical speculation to a science based on "empirical" evidence operating in the sanitized (re: depoliticized) spaces of the laboratory. The battle against neo-Lamarkianism would represent the first and the rise of genetics the second.

The hero of modern evolutionary theory is, of course, Charles Darwin. In prior chapters, I sought to distinguish Darwinism from evolution broadly and to understand the developments recorded in this chapter I must do the same. Thus, I will begin with the essence of Darwin's evolutionary ideas, at least those ideas which were relatively unique to him and would become widely accepted over the course of the twentieth century. In his masterful study of *The Structure of Evolutionary Theory* (2002), Stephen J. Gould divided Darwinism into three essential tenets or pillars, (a) natural selection is the primary explanatory force for the origin of new species through the selection of small, undirected variation, (b) natural selection operates at the level of the organism, (c) small, infinitesimal, adaptations on the level of the organism (microevolution), gradually "add up" to larger scale changes in species and life on Earth in general (macroevolution). In general, it was the first tenet that bothered critics of Darwinism from his day to the present the most while the latter two tenets generally occupied the attention of those in the field evolutionary biology itself. It would be incorrect to add a fourth, though commonly assumed tenet to Darwin's thought--that characteristics acquired during an organism's lifetime could not be transmitted to their offspring (the Lamarckian or "soft inheritance" position) as even Darwin accepted this possibility later in his life, though the debates between the neo-Darwinians and neo-Lamarckians at the turn of the century would have one conclude otherwise.

Gould's system allows me to extrapolate the debate over evolution from biology and locate it in the larger context of the history of ideas in the West. The position that Darwin took and the radicality of his work, according to Gould, was articulating a fully adaptationalist or functionalist account of the existence of divergent species in contrast to the formalist accounts that had existed before Darwin's time. Further, Gould continues, the success of Darwin's account depended on his recognition that the adaptationalist position must be historicized if it is to work. The question I will ask is why was this account so attractive to twentieth century American biology? How does "functionalism" function in the US society? Before I take this problem up, I want to add a bit more to Gould's distinction. While Gould is correct that European thought was mostly grounded in an idealist or formalist position, including European biology, the historicist tendency I identified previously (including a range of thinkers-from Hegel and Marx to Nietzsche) recognized that the "ideas" of formalism were generated in history or practice. In other words, nineteenth century European formalism was, in its most critical variants, a materialist formalism, or in other terms, a neo-idealist adaptationalism.

In contrast, Anglo-American thought remained mired in empiricism, leading the US variants of evolutionary thought (arguably including Darwin himself) into a neo-empiricist adaptationalism. While this might appear to be an unimportant point, it forces one to consider the reality given to concepts or ideas. In the European variant of evolution/historicism, ideas, although grounded in practice, are real. In contrast, in the Anglo-American version they are not. They are simply abstractions invented by scientists. Without concepts (including the concept of species), as I have implied in my depictions of a critical science, one is left with an understanding of the world that reifies and naturalizes the status-quo. A critical evolutionism becomes impossible. Why then was this latter version of evolutionary thought so successful in the United States? A conclusive answer, which I will return to in the final section of this chapter, has to do with Darwinism's ability to occupy a homologous place in US thought to the one empiricist science had already established-it could hide its penultimate conservatism under a mask of progressivism-biological forms (humans included) were in a constant process of development (progressivism) though these developments took place over such large scale time periods, are results of adaptations to a relatively static "environment," and are random thus humans have little or no control over them (conservatism). But, I am getting ahead of myself, as Darwinism barely survived the nineteenth century.

1. The "almost" eclipse of Darwinism

The idea that natural selection was the primary creative force in explaining the origin of species was the most difficult idea for Darwin's critics to accept. While Darwin himself accepted that natural selection presupposed variation (differences which were to be selected) and heritability (those differences had to be transmitted to offspring), without natural selection neither variation--as changes were both small and random--nor heritability could get rid of unsuccessful species (the negative version of natural selection) nor, and this is key, produce novel species. While many of Darwin's critics could accept the importance of the negative form of natural selection, they could not see how the positive form could be such a crucial force in evolution (e.g. Mivart). Thus, many posited alternate explanations of novelty including large-scale variations in the course of a generation (e.g. mutationalism, saltationalism), the inheritance of acquired characteristics (neo-Lamarckism), or the presence of an innate force which guided evolutionary change (orthogenesis).

By the turn of the century, not much had changed, except that Darwin's solution was growing ever less popular. There are several reasons why this was so-some related to debates within biology itself (whether or not natural selection was "empirical" enough) and the seeming improbability of natural selection being as important as Darwin had argued. Other objections related to the rejection of the kind of social Darwinism which had permeated Anglo-American society, leading to a general consensus that this kind of competition could only be a negative force. Two of the most famous saltationists of the late nineteenth century were Hugo De Vries and William Bateson.

De Vries is well known today for his work on mutations and as one of the re-discoverers of Mendel's work (along with Carl Correns and Erich Tschermak-Seysenegg) in 1900. De Vries began his career trying to reaffirm Darwin's theory of pangenesis (that the basic hereditary mechanism was the transmission of gemmules from parent to offspring who received a "blending" of each of the parents characteristics) and was not very interested in working through the implications of Mendel's work as they appeared, at least in 1900, to be profoundly anti-Darwinian; that is, as Mendel's work only explained the distribution of parent characteristics among offspring, it did not offer the source of new variation (Gould 2002). Thus, in contrast to what is commonly assumed, Mendelianism began its re-emergence in 1900 as a critique of Darwinism and the creativity of natural selection. While De Vries first discovered the presence of mutations in 1886, he developed a full blown mutationalist theory of evolutionary novelty in his two part masterpiece *Die Mutationstheorie* published in 1901-3 (published in English as *Mutation Theory* in 1909). De Vries's mutation theory was an extension of his experimentalism and his wish to see biology emanate the results of physics and chemistry. Just as chemists and physicists assumed atoms were discrete, measurable units, so too one must assume about the properties of organisms. Thus, one cannot expect to find transitional forms in either case. Further, De Vries rejected Darwinian gradualism as it was not amenable to experimental study (Gould, 2002). Against Darwin's gradualism, De Vries speculated that new species arise through a special kind of saltational variation which he called mutations.

William Bateson developed a similar theory of discontinuous change. Bateson's *Materials for the Study of Variation* (1894) presents his own version of saltationalism. Bateson began his study by taking issue with what he regarded as a bias of most accounts of variation, that of gradual and continuous change. Bateson instead argued that discontinuous or "meristic" variation was the primary source of evolutionary change. Bateson's account rings of the formalism of the great taxonomists before him. He was primarily interested in "types" of biological structure which exist in complete form, thus cannot be formed gradually and continuously nor selected for over the course of time. To this, Bateson added that changes in structure, rather than being the result of history, are a result of chemical and mechanical forces operating during development. This drew him to theories of heredity and later, Mendel's work, which again was regarded as anti-Darwinian. These structures are useful, not because they adapt to environments, but because of their intrinsic nature as constructed through a hereditary mechanism. Like De Vries, Bateson was an experimentalist and not interested in evolutionary histories or the "storytelling" of the adaptationalists. In 1905, after recognizing that Mendel's work provided him with the hereditary mechanisms of discontinuous change (remember some of Mendel's peas looked nothing like their parents), Bateson invented the word genetics and founded the *Journal of Genetics* (Gould, 2002). Later in his career, Bateson continued his opposition to all adaptationalism (neo-Darwinism and neo-Lamarckism alike) and whose passion against this work was well documented in Arthur Koestler's (1971) *Case of the Midwife Toad* which tells the tale of Bateson's elaborate project of proving that the results of the neo-Lamarckian, Paul Kammerer's studies, studies which appeared to prove the possibility of the inheritance of acquired characteristics, were fraudulent.

The other key non-adaptational theorist of this period was D'Arcy Thompson. His *On Growth and Form* (1917) laid out the fullest expression of the formalist position. Thompson rejected functionalist and historical explanations of the origin of biological form and explained instead that one can understand evolution through basic physical forces acting on things themselves and the effects they have. For Thompson, the adaptationalist arguments conflate, in Aristotelian terms, a "final" cause with an "efficient" one, while only the latter kind need be evoked by science. He, instead, goes on to describe the forces which act on organisms from uni-cellular to multi-cellular ones, illustrating that, at different levels of complexity, a particular force as well as its effects become radically different. In empirical chapters, Thompson goes on the show how uni-cellular organisms which dwell in a world of forces acting on their surfaces (thus surface-tension becomes a key factor) exist differently than larger ones, which are ruled by forces like gravity and rate of growth. Although Thompson was widely respected and his work widely read-- especially by the growing environmental movements of the 1960s who lauded Thompson's respect for the diversity of life--his basic ideas were rejected when the "modern synthesis" was formulated.

Finally, one of the only major saltational theorists of the mid-twentieth century, Richard Goldschmidt, would come to undergo the scorn of the adaptationalists by the time natural selection began to make its comeback in the 1930s and 40s. His *Material Basis for Evolution* (1940) argued that new species arose saltationally, through genetic mutations which altered the way an organism develops (although he did accept that natural selection could preserve existing species), through the birth of what he infamously called "hopeful monsters" (in that they are, by chance, well adapted and developmentally workable mutations). By continually denying natural selection the power to produce novelty, Goldschmidt happily upset those who sought to establish the "modern synthesis" and restore Darwinism to its rightful place. Along with the saltationalists, orthogenesists like Theodor Eimer (in his *Orthogenesis of Butterflies*) argued that natural selection could not direct evolution. However, instead of turning to discontinuous variation, he explained evolution through an organism's internal channels regulated by "laws of growth." Eimer, however, rejected that this process was in any sense vitalist (as say, in the case of Bergson), but simply a result of natural processes and material, physical causes. For him, Darwin had simply surrendered too much to chance and Eimer sought to apply the determinism of Newtonianism to evolution, again like the other thinkers discussed, in the interests of turning evolutionary study into an experimental and predictive science. This point is worth dwelling on. Darwinism could not become hegemonic in evolutionary science as long as it could not become a predominately laboratory and experimental science as this was the direction physics, chemistry and the other successful sciences had taken.

Darwinism itself had also undergone significant modification by the turn of the century through the work of its most ardent supporter, August Weismann. Weismann found himself involved in a public debate with Herbert Spencer in 1893 after Spencer published an article denying natural selection the importance neo-Darwianians like Weismann gave it. Instead he advanced a version of neo-Lamarckism-while selection was important, the inheritance of acquired characteristics was most crucial for the generation of novelty. Weismann responded in a paper entitled "The All-Sufficiency of Natural Selection," (*Die Allmacht der Naturzüchtung*-parodying Spencer's title "The Inadequacy of Natural Selection") offering the classic panselectionist position-selection was the exclusive force of evolutionary change--and with this the turn of the century debate between the neo-Lamarckians and neo-Darwinians began. Both positions were distortions of Lamarck and Darwin. Neo-Lamarckism ignored some of his more basic ideas around the life forces which propelled evolution and focused only on the idea of "soft" inheritance, an idea which others in his day espoused as well, and neo-Darwinians "forgot" that Darwin himself had accepted the possibility of the inheritance of acquired characteristics playing a role, albeit lesser role than selection, in evolution (Gould, 2002). Also, both positions share a basic functionalism which contrasts with the formalist positions I have just discussed. Neo-Darwinism was taken up by the students of Galton and the school of biometry, who sought to use statistics to describe the variation in populations and use them to study continuous variation. As is well known, as the new century progressed, neo-Darwinism and neo-Lamarckism became more clearly marked as political rather than scientific positions-particularly the latter which was dismissed as the "political" one with the modern synthesis while the former became the "scientific" one.

Weismann's famous distinction between the immortal germ-plasm and the limited soma-plasm-the latter constructed via the information contained in the former--offered a framework for the soon to be rediscovered genetic theory of Mendel (which would definitively prove the erroneous nature of conceptions of "blended" inheritance), and explained theoretically why Lamarckian inheritance was impossible--the path of information from gene to organism was uni-directional. Once Lamarckism was set aside, for Weismann, selection became the only viable force for evolutionary change. For him, selection need not operate at the level of the organism but at the level of the germ--germinal selection-thus what might appear like the product of soft inheritance or even the product of a saltationary/orthogenetic process, was actually an expression of an already selected for germ-plasm. Thus, contra Darwin, while variation appeared to be directed, at least on the level of the organism, on the level of the germ-plasm it was not. Selection remained as random as Darwin had described. Many critics of Weismann argued that this new understanding of selection was simply trying to salvage the importance of natural selection, one which most scientists had already come to reject (Gould, 2002). However, as Ernst Mayr (1982) points out, Weismann was prescient in the sense that he recognized that in genetics lay the key to variability. Mayr even went so far as to call Weismann the most important nineteenth century evolutionist after Darwin.

Much of the scientific world at the turn of and well into the twentieth century could not accept some of the basic assumptions of Darwinism. This revolved around the importance assigned to natural selection and all that this implied. For instance, in order for natural selection to be an important force, variation had to be random, or at least, undirected. If this was not the case, then variation would be mostly responsible for evolutionary change and not selection. The idea that evolution was left mostly to chance, then, was a hard pill for many to swallow, not only for those in the religious world. Even naturalists who reveled in the elegance of the living world were reluctant to accept this (Bowler, 1989). They suggested that variation was guided by the intelligent activity of individual organisms, or by forces inherent to the processed of individual growth. This was the kind of teleology implied in the neo-Lamarckian, saltational and orthogenetic perspectives.

One can understand the reluctance to embrace the crass materialism of the Darwinist position if one recalls some of the other revolts against the dominance of rationalism and science I discussed previously which were critical to this period. In aesthetics, religion, and science alike, one witnessed a critique of modern life which took exception to the narrowness and crude mechanism of the scientific perspective, a critique which became more vocal after the First World War. French philosopher Henri Bergson expressed this critique in his vitalism and in terms of his distaste for the mechanist principle implied by Darwinism. As he put it, "the vitalist principle may indeed not explain much, but it is at least a sort of label affixed to our ignorance, so as to remind us of this occasionally, while mechanism invites us to ignore that ignorance (cited in Koestler, 1971, p.31). Ironically, most "selectionists" were themselves as invested in a "purposive" or "progressionist" view of evolution as their formalist and non-adaptionist counterparts. Although it is correct that the randomness of variation in selectionist theory from Darwin on is intended to rule out a progressive evolutionary narrative, that is, a simple, ordered passage from lower to higher species, it is also equally clear that most evolutionists believed that species have increased in complexity and ability to adapt to their environments over time (particularly humans). Explicit statements toward this end tended to come in popular writings of evolutionists rather than in their professional work (Ruse, 1999). The term "evolution" itself was not neutral. It implied a theory of progress, though of course selectionists continually denied this. The difference between the warring groups of evolutionists often came down do political questions. How much can humans intervene in controlling the processes of evolution? For the neo-Lamarckians the answer seemed to be a great deal, while strict Darwinists seemed to hold on to the idea that change comes gradually and piecemeal, and that human intervention was at best hopeless and at worst, an impediment to the natural processes of selection.

In these years, those that sought to turn biology into an experimental science, with the consequent prestige and funding it implied, generally turned away from Darwinism rather than toward it. In general, many leading Darwinists were not in universities but in museums of natural history and were thus in the business of creating narratives about the origin of life which the visiting public could easily consume (Ruse, 1999). The adaptationalist position offered such compelling narratives. In contrast, formalist positions (which include the geneticists) were more firmly ground in the universities themselves (particularly European universities), even those that accepted evolution as fact. Those Darwinists not in museums tended to get their funding from projects related to agricultural production, and again, ended up being regarded as second-rate scientists (Ruse, 1999). This split created an inherent instability in the discipline of evolutionary biology and would have to wait until the synthesis for the selectionist and geneticist positions to come together.

With respect to textbooks, one would expect that the variability of evolutionary mechanisms with a basic acceptance of evolution itself would be translated into high school science texts. Before the turn of the century, naturally, biology texts did not include much mention of evolution, particularly in the US, except an occasional mention of its "absurdity" (Larson, 1985). Biology generally included botany and zoology and was framed as nature study. In essence, the study of biology was an expression of the dominant formalisms of the taxonomists. The goal, in the words of one text, was to provide "an intelligent and appreciative attitude toward nature" (Llyod and Bigelow, 1907, p.13) with a focus on "elementary agriculture and horticulture" so that the distinctions inherent in nature are appreciated. But already by this point, talk of adaptation had seeped into biological language as the authors asked functionalist questions and "inquire[d] into the behavior or purpose of the mechanism; and the answer should be sought by the experimental method" (58). Offering an example of the bending of roots in soil, these authors explain this is due to its more effective distribution, clearly an adaptationalist oriented explanation. Not surprisingly, there is no mention of selection and only a brief mention of a "struggle for existence." The source of the bended root could just as easily be divinely inspired.

Botanist Asa Gray was one of the first school-book authors to mention evolution. In his *The Elements of Botany*, a republished version of an earlier text which did not mention evolution and had referenced a "creator," he argued that "nearly related species probably came from a common stock in earlier times" (cited in Larson, 1985, p.10). Later, without using the word "evolution," Gray made the important selectionist presupposition that a tendency to variation pervades all living things. In 1895, geologist William North Rice revised an earlier textbook by the anti-selectionist James Dana to affirm the evolutionary development of species, but adding that this development has been guided by "infinite Wisdom." By the end of the century, Charles E. Bussey's popular high school text, *Botany,* explicitly privileged an evolutionary perspective over a creationist one and Joseph LeConte's (1887) geology text explicitly said "Geology is... a history of the *evolution* of the earth and its inhabitants" (cited, Larson, 1985, p.16). By 1900, horticulture professor Liberty Hyde Baily went so far as to name a section in his text "The Fact of Struggle for Existence." Finally, George Atkinson's *Botany for High School* asserted that evolution "has been accepted because it appeals to the mind of man as being more reasonable that species should be created according to natural laws rather than by an arbitrary and special creation" (cited in Larsen, 1985, p.20).

A study of twentieth century biology textbooks before 1920 counted 18,498 words dealing with evolution, 3949 with Darwin and 2092 dealing with selection. Only 98 words dealt with special creation (Larson, 1985). Perhaps the most infamous book of the period, the one William Jennings Bryan would rail against in the Scopes trial, was George W. Hunter's (1914) very popular, *A Civic Biology*. There, Hunter went so far as to say that "man is the product of evolution." (cited in Larson, 1985, p.21). While evolution meant something far broader than selectionism or Darwinism, by 1920 and the beginnings of the anti-evolution crusades, it was apparent that evolution had trumped creation in biology texts as the primary explanation for the origin of life. Thus, the problem for creationists was not selection, per say, but simply the widely accepted notion of evolutionary descent, an idea that preceded Darwin by decades. Still, most texts did not make this distinction and lay responsibility for all evolutionary ideas on Darwin. The great majority of these texts did not suggest that selection was the exclusive or even dominant form of evolutionary novelty, some were vague on this question and others took an explicitly neo-Lamarckian position. After the evolutionary wars of the 1920s, references to evolution tended to become even more vague, usually referring to it as simply a "theory," and there was a marked return to formalist rather than functionalist explanations of the origin of species. This trend is well demonstrated in one of the science reform documents of the 1930s in which it was argued that high school biology should concentrate more on the kind of taxonomy and morphology it had focused on in its earlier days instead of on "behavior" and "functions." In another instance, Wheat and Fitzpatrick's *Advanced Biology* (1936) refers to a "struggle for existence" but seems to suggest that this is mostly involved in negative forms of selection and leaves the creation of evolutionary novelty up to mutations and other saltational processes. This was the case until the return of selectionism in the curricular reforms of the 1950s.

2. The First Synthesis: Making Evolutionary Change Gradual and Non-Directed

The modern synthesis rejected the idea that any other mechanism aside from natural selection could be the dominant force in evolution. Ernst Mayr, one of the architects of the synthesis, characterizes it as a "meeting of the minds" (1982, 567). Given the objections documented, one would expect this to be a difficult process. Yet surprisingly, in many ways, it was not. There was remarkable unanimity among evolutionary scientists (with few outspoken exceptions like Goldschmidt) that this was the way to go. To figure out why this was the case, I will review the synthesis itself and then the society within which it took hold.

While the writings that made up the synthesis began appearing in the 1930s, it was Julian Huxley's *Evolution, The Modern Synthesis* (1942), which gave the movement a title. The early works of the synthesis had to reconcile the anti-Darwinism (saltationalism) of the geneticists and the study of natural selection now taken up by the biometricians. At this time, the focus of the biometricians (or naturalists) and geneticists were radically different. While the former focused on the origin of diversity (particularly at the level of the species) and saw gradualism everywhere, the latter focused almost exclusively on transformation (rather than already existing diversity, some of which would be selected) (Mayr, 1982). The problem was to explain how small scale, continuous variations-as Darwin had characterized them-could lead to major evolutionary change without being "swamped," so to speak; that is, simply erased because of a tendency of population characteristics to drift toward the average (what Galton had called, "regression to the mean" (Bowler, 1983). R.A. Fisher provided a mathematical solution to this problem. In *The Genetical Theory of Natural Selection* (1930), Fisher explicitly rejected the position of the early geneticists, that Mendel's work had lead a death blow to natural selection, and argued that the situation was quite the opposite as a particulate theory of inheritance did not necessarily imply discontinuity in evolution. He proved that small-scale genetic changes (later recognized as variation already present in a population), through the pressures of selection, can have a large effect when one looks at the population as a whole. Those random changes which make an organism more fit tend to increase in number with each successive generation. Fisher's mathematical solutions proved attractive to evolutionists who were beginning to establish themselves in universities and sought a more "rigorous" method for their work.

Fisher was unique in his understanding of mathematics, but the Russian biologist Theodosius Dobzhansky laid out the new union of Mendelism and Darwinism in his influential *Genetics of the Origin of Species* (1937). In that work, Dobzhansky explained (and demonstrated with the beloved species of evolutionists, *Drosophila*) that the principles of experimental genetics can explain evolution at all levels. Gould (2002) points out some of the changes in Dobzhansky's work over time. In the original edition, he lists natural selection as his "preferred" method but allows for other methods of evolutionary change including "genetic drift" (Sewall Wright's conception of a counter force to selection whereby change was nonadaptive and accidental as, in small populations, mating patterns can cause genes to be mixed together randomly) and migration. By the third edition in 1951, Dobzhansky increases the power and scope of selection, downplaying other alternatives and allowing little room for nonadaptive changes in biological form. Dobzhansky's work, more than any other architect of the synthesis, was central to establishing the boundaries of the research programme which evolutionary biology would now take up (or be limited to).

Gould (2002) demonstrates that in many architects of the synthesis, a "hardening" of their positions on the importance of natural selection took place as later editions of their work were published. The question to ask, of course, is why? Gould's offers one answer. He rejects the naïve idea that the shift in focus was data driven and argues that, following the devastation of the Second World War, a renewed optimism put its faith in evolutionary progress and the possibility of humans beings to improve, or "adapt better to," their world. There is truth to Gould's thesis, but his explanation leaves out much in what was at stake in these (non)debates over natural selection. For instance, wouldn't an interest in optimism privilege a neo-Lamarckian rather than selectionist perspective, the former offering humans more ability to permanently transform their world?

The answer is no, as, by the close of the war, neo-Lamarckism, now conflated with the unscientific Lysenkoism of the Soviet Union, became one of the most scorned terms in biological thought (Oyama, 1985). If Darwinism was the expression of freedom, of democracy, of Adam Smith's invisible hand organizing evolution, neo-Lamarckianism was its opposite, representing authoritarianism, repression and "controlled" evolution (homologous to the Soviet Union's failing command economy). The neo-Lamarckianism of Lysenko, however, was less a "scientific" theory, particularly in its early days, than what seemed like a practical solution to the problem of Soviet agriculture. In the early years of the Soviet Union, Lenin and others were frustrated by an odd paradox: while Soviet scientists appeared to be far more advanced when it came to agricultural and botanical theory than their Western counterparts, Russian peasants still clung to the grain-fallow rotations of their medieval ancestors (Joravsky, 1970). These techniques produced limited yields. As Lenin and later Stalin sought to industrialize the Soviet Union, more agricultural output was needed to feed those that would now work in the factories. Hence, the violent forced collectivizations of 1929 and so on. Until 1929, Lenin and Stalin both had deferred to "experts"-in the Western scientific sense-to solve the problem of food shortages. However, in 1929, Stalin shifted Soviet policy and sought to develop a "bolshevized" science. At the same time Trofim Denisovich Lysenko, a "peasant" scientist, claimed that he discovered a process he termed "vernalization" which dramatically increased production.

Over the 1930s the so-called legitimate scientific establishment and the Lysenkoists, or agrobiologists, bitterly fought each other for control over Soviet agricultural policy. The scientific establishment, mostly geneticists, generally objected to Lysenko's incipient neo-Lamarckism, his suggestion that he could somehow change future generations of seedlings by conditions he created for their parents. Lysenko seized the opportunity to turn the feud into all out ideological battle between the bourgeois "theoretical" specialists and the proletariat "practical" agrobiologists, a battle line Stalin himself approved of. Eventually, Lysenko's attack on agricultural techniques turned into an all out attack on genetics. The rest of the story is well known. By 1948, Lysenkoism was decreed the official agricultural policy of the Soviet Union with all others banned, but Lysenko's promises did not live up to the reality of Soviet food needs. After Stalin's death, the Soviet's began to gradually back away from Lysenkoism and reinstated a "discussion" on genetics. In its early years, Lysenkoism represented to many a Marxist inspired hope that radical changes in the present could produce changes in the future. In the US, the ultimate repudiation of Lysenkoism, of trying to "control" too much, offered US officials and scientists a way to denounce communism as its theories had failed so dramatically when applied to biology. Naturally, the same was assumed to be true for economics and politics. Social conditions simply don't change as dramatically as the Soviets had implied, or at least, not for long. There is no question that Lysenkoism was a politicized science, but as I will soon argue, the same is true for genetics. The "Lysenko Affair" says very little about the reality of soft inheritance (except perhaps that Lysenko's variant was far too crude) and much more about the politics of the Cold War.

In the same sense, the modern synthesis was a consolidation of evolutionary theory that was as much political as it was scientific. The years between 1930 and 1960 were ones in which the US sought to hypostatize a kind of nationalism and patriotism which would be used to counter the threats of totalitarianism from the Nazis and the Soviets. Many evolutionists took advantage of this in terms of funding. Dobzhansky and his students, for instance, received funding to demonstrate that radiation artificially introduced into the atmosphere had little deleterious effects, thus the buildup of the US's nuclear arsenal was not dangerous (Ruse, 1999). In fact, many authors of the synthesis (Mayr, Simpson) devoted much of their popular writing to defending "democratic" societies and their immanent connection with evolutionary thought. As evolutionary theory moved away from museums and into universities it would have to become more "scientific." Only by framing evolutionary research in these terms, particularly in connection with genetics, could evolutionists hope to gain the prestige and funding accorded to the other sciences.

As evolution unified itself under the modern synthesis, it became another expression of the tension between progressivism and conservatism which frames Western democracies and the United States in particular. Change was inevitable, so was development. Thus, the US could position itself, as a consequence of its achievements in science and technology at the pinnacle of development (yet always open to further development). On the other hand, some inequities in social relations had to be the product of "natural" rather than human forces. Whether one looked to Smith's "invisible hand," Spencer's "survival of the fittest," and so on, Americans were made to realize that, while the gaps in wealth, political power and prestige that divided them were destined to change due to the fact that US society (like the natural world) was continually developing, these were not changes that could simply be made by government. Instead, these changes were to come from nature itself, in a slow and continuous way which is often unnoticeable to the untrained eye. If nineteenth century social Darwinism was attractive to certain Americans because it rationalized the inequities of US capitalism, mid-twentieth century Darwinism was equally attractive because it rationalized similar inequities, all the while offering some hope for the future. This helps to explain why the formalism of the non-adaptationalist and especially the orthogenesist positions were so unappealing to the Anglo-American world yet flourished in Continental thought for much of the twentieth century. In the latter, social positions operated within a universe where things existed as they were supposed to and, contrary to the foundational ideas of US society, tended to remain that way, removing the glimmer of hope US society is so well designed to give those that are less successful within its system.

With respect to high school biology texts, Gould (2002) points to a similar "hardening" of the selectionist position, particularly in the BSCS curricula I reviewed in the prior chapter. As Gould points out, the high school biology texts of the 1960s and 70s (those influenced by the BSCS curricula) tended to take for granted both gradualism, extrapolationism (that the processes of microevolution can be extrapolated to macroevolution) and that the primary source of evolutionary change was natural selection. This is not hard to demonstrate. Take the text *Biological Science: An Inquiry Into Life*, the 1963 revision of the BSCS Yellow version. Already, in terms of literal space allocated for topics, more space is given to genetics than evolution. A late chapter entitled "Darwinian Evolution" tells of Darwin's conception of natural selection describing his theory as "so close to the modern view that it serves as a convenient introduction to the subject" (589). After laying out Darwin's theory and, not surprisingly, making the connection between Darwin, Weismann and modern genetics, the book goes into the details of Lamarckian inheritance even admitting that "there have been other theories to explain how evolution occurs, but none has been established as "true [although] ...the Lamarckian account of the development of change is simple, clear, and attractive, but unfortunately wrong... [as] ...no evidence exists to support it" (594-6). While it is never made clear what makes Lamarck's theory more "attractive" (presumably its political implications), it is clear that the ultimate vindication of selectionism is in genetics although "Darwin's concept of natural selection [is] now supported by a large number of experiments performed with all the care and precision that modern biology requires" (598). With respect to the "problem" of the fossil record as well as some of the other evidentiary contradictions to natural selection that its critics had marshaled against it for over a century, the text ignores them altogether. Missing from these accounts is that the triumph of selectionism was due less to the precision of biologists than the force of the architects of the synthesis and the desire to scientificize selectionism.

3. The Second Synthesis: Making the Mechanism of Inheritance Uni-Directional

Weismann's work and the developing uni-directional models of inheritance made ontogenesis (development) irrelevant--as it also did to use-inheritance--because adult bodies were simply expressions of genetic instructions. The disciplinary stage for Watson and Crick's discovery of the double-helix was set well in advance, a discovery which would explain this process in structural and functional terms, an explanation that was anticipated long before the "discovery." The ground had already been prepared earlier in the century as the disciplines of embryology and genetics began to diverge. As Evelyn Fox Keller (1995) perceptively notes, while the term "heredity" had originally referred to both transmission of potentialities during reproduction and the development of those particularities over life, after the rediscovery of Mendel's work the term was increasingly used to describe only transmission. The new field of genetics explicitly renounced embryology. As T.H. Morgan described it in 1926, "...the theory of the gene, as here stated, states nothing with respect to the way in which the genes are connected with the end-product… the fact remains that the sorting out of the characters in successive generations can be explained at present *without reference to the way in which the gene affects the developmental process* [my emphasis]" (cited in Keller, 1995, p. 5). Morgan even went so far as to postulate that "whatever the cytoplasm contributes to development is almost entirely under the influence of the genes carried by the chromosome, and therefore may in a sense be said to be indifferent" (cited in Keller, 1995, p.7). Because genes were regarded as autocatalytic, that is, able to independently replicate themselves, they did not require anything but their own "will" to transmit hereditary information. Keller refers to this way of thinking about genes as the "discourse of gene action," a vocabulary that offered genes far more agency, autonomy and causal responsibility that they actually have.

The only ones to recognize this problem were the embryologists, who were familiar with development and thus, the complexity of actual living organisms. They argued that the effects of genes on an organism, like the effect of environments on organisms, are emergent properties of developmental systems and do not preexist them. Not surprisingly it was European embryologists who recognized the flaws with the Anglo-American dominated discourse of gene action. One of these critics was formalist Richard Goldschmidt who spoke of "gene activation" in complex systems rather than gene action. The discourse of gene action threatened the very foundation of the embryologists' discipline as the question of how a germ cell develops into a multi-cellular organism, the question of differentiation, was almost irrelevant. For the geneticist this was not even a question, as clearly, the genes simply directed the process. Others too criticized this gene-centered discourse including Joseph Needham and C.H. Waddington. In the 1930s with the rise of Fascism, as embryology became associated with German science, it was further marginalized. Furthermore, as Keller points out, it is hard to miss the gendered tropes of nucleus and cytoplasm--male and female--with the latter being dismissed as irrelevant. When molecular biology took up the processes of protein synthesis in the 1950s and 1960s they did so with simple organisms working on the assumption, as Jacques Monod famously put it, "What's true for *E. Coli* is true for the elephant."

Another figure who tried to complicate the discourse of gene action was geneticist Barbara McClintock. She had pointed out in the early 1950s that genetic elements could move spontaneously from one site to another, even one chromosome to another, a phenomenon she referred to as "transduction." The consequences of this were profoundly challenging to genetic orthodoxy. No longer could genetic information be regarded as coming from a static, fixed source, but instead its source was dynamic and mobile. Geneticists ignored her work until the late 1960s when independent evidence for transduction emerged. The divergence of embryology and genetics would have its consequences in the simplistic models of protein synthesis which ignore the rest of the intra and extra cellular contexts in which proteins are produced as well as the kind of genetic determinism which became increasingly popular in the 1970s and survive up to the present day.

Molecular biologists had long suspected that the key to the transmission of hereditary information lay with proteins. As historian Lily Kay (2000) explains, the idea of the genetic materials as possessing "information" and later "instructions" began as a metaphor, but gradually became more and more real in the minds and theories of biologists. While mechanistic biological discourses had long characterized the body as a machine, physicist Erwin Schrödinger's popular *What is Life?,* became one of the first texts to fully lay out the new informatics discourse for biology. Naturally, this work was shaped by the success of the informatics model in technological developments related to the war and DOD research.

Finally, Watson and Crick's "discovery" of the double helix codified and materialized the metaphor. The developing information discourse was profoundly affected, first by developments in computing during and immediately following the Second World War, and more broadly, through its circulation in the military-industrial complex of the Cold War era. Kay argues that the informatics discourses exceeded molecular biology and became widely accepted "mainly as a result of their transdisciplinary and cultural resonances and because of their efficacy as models and analogies in the process of biological meaning making" (11). In addition because, technically, the idea of information could be divorced from its "content," (it is precisely not "meaning), it could supply molecular biology with a language to talk about genetic transmission without necessarily having any sense of what was being transmitted. Monod, seeking to move the French away from neo-Lamarckism, characterized heredity as nothing but "information, message and code" (1970). The model/metaphor was there long before the actual "discovery."

Developing models of genetic transmission were affected by the organisms studied--*Drosophila, Neurospora* spores, *E coli* bacteria and other uni-cellular organisms with the idea being that one could extrapolate what one discovers about these processes to multi-cellular organisms like humans. Naturally, this lead to models of reduced complexity. Still, the actual process of genetic reproduction and transmission was a mystery. Thus, ironically, the role of genes in the body was well accepted decades before anyone knew much about the material form or function of genes. It was, for all practical purposes, a given. Another given was that the genetic substance, whatever it was, was able to reproduce itself or autocatalytic. Thus, by the time Watson and Crick came along, they simply had to devise a genetic structure that fit with the assumptions of uni-directionality, autocatalytic reproduction and basic independence from the rest of the cell's activity.

The story of the 1953 "discovery" is well known through Watson's personal account in *The Double Helix* (1968). There Watson admits that "all we had to do was to construct a set of molecular models and begin to play" (51). Reading Watson's account, one sees just how much of the discovery was "guesswork," Watson even going so far as admitting that he did not understand some of the basic aspects of helical theory even as he was devising models for the helix structure of DNA! Watson and Crick presented their model at the 1953 Cold Harbor Symposium on viruses. In 1957, Crick referred to the idea that information could go from nucleic acid to protein but not the other way around as molecular biology's "central dogma." Ironically, Watson and Crick had not specified the solutions to the two most important questions which occupied geneticists, (a) how did DNA reproduce itself? And (b) how was it involved in the synthesis of proteins and therefore the transfer of hereditary information? Yet somehow, many molecular biologists accepted Watson and Crick's model because it seemed to point to the answer to these questions, leaving the presumption of uni-directionality intact. Also, the sequence of bases making up DNA could easily be read as a form of coded instructions for producing fully developed organisms. As Watson put it in 1957, the sequence hypothesis assumes that "the specificity of a piece of nucleic acid is expressed solely by the sequence of its bases, and that this sequence is a (simple) code for the amino acid sequence of a particular protein" (cited in Keller, 2000, p.52). These proteins were the building blocks of organisms which acted according to the predetermined "instructions" of the DNA.

It took years for developmental biologists to articulate some of the basic flaws of the gene-centered model of hereditary transmission, or at least, to get anyone to listen. Most practicing molecular biologists still regard genes as the primary agent "behind" organismic construction and development and one finds mostly this discourse circulating in contemporary culture. Ironically, the "model" was developed long before any knowledge of the structure or function of these processes was acquired, suggesting that this model was profoundly political, both allowing molecular biology to begin to "master" life as well as to begin to hint that the inequities in US society were biologically rather than culturally based. Finally, the rapid success of genetics demonstrates something interesting about US society-its willingness to embrace formalist leaning models (which are couched in functionalist discourses) rather than functionalist ones. Although it is widely agreed that the function of DNA had to be related to its structure (the helical combination of the bases adenine, thymine, guanine and cytosine), the central dogma offered only one version of the process by which "information" from the DNA was communicated to the body; in other words, the process, although likely an "evolutionary adaptation," was basically immutable. Here, perhaps, is yet another instance of Anglo-American rigid formalisms disguised as particulate historical adaptations, which turn out to be universal and a-historical.

It should come as no surprise that the new central dogma of molecular biology would quickly find itself in high school biology textbooks. As I suggested before, in terms of space, it was accorded far more space than natural selection. Of course, genetics feels more scientific as its processes can be studied in laboratories and easily "looked at" while evolution remains a background assumption, more speculative than scientific. When one looks to much of the BCSC curricula one finds this to be precisely the case. Evolutionary thought is generally introduced in an early chapter, as sort of an a priori (though an abundance of evidence is generally referenced but never offered) and several chapters are devoted to explaining genetics including Mendelian genetics, DNA structure/Protein synthesis, and the inheritability of phenotypic characteristics. In *Biological Science: An Inquiry into Life*, the basic ideas of the central dogma are laid out explicitly. For instance, reproduction is described as "a mechanism ensuring that all daughter cells receive DNA identical or nearly identical to that of the parent cell" (146). Leaving aside Barbara McClintock's notions of transmutation which problematizes these kinds of "identical or nearly identical" translations, one wonders whether cellular reproduction is exclusively about transmitting exact copies of DNA. What about the cytoplasmic contents of a mother's egg in the case of human reproduction? Is that not also a part of reproduction? Further, the text continues, "DNA is believed to be the substance that controls the activities of the cell" (146). Or later, "the genes control, by their *actions* each and every step of an organism's development, from the first effects in the zygote, through the development of the embryo or seedling, to the full functioning of the adult (559).

Many thoughtful contemporary biologists would disagree with this claim and argue that RNA, other proteins--particularly enzymes-as well as other cytoplasmic and developmental contents/contingencies "control" the activities of the cell. "Control" is not even the right word. Watson and Crick's work and the work that followed on protein synthesis, while important, did not come close to "proving" that DNA controls the activities of cells. Later versions of the curricula (the 1968 revised BCSC Blue Version) do complexify the process a bit (e.g. admitting that DNA cannot act directly on cells and the possibility of gene "transfer"), but still hold to the fundamental assumptions of the discourse of gene action. It is not only that this discourse simplifies, reduces and even distorts biological processes-all of which it does-but it offers DNA as the "master molecule" endowing it with autonomy, agency, almost "thought," supported by the general consensus of the so-called scientific community. The text, of course, never bothers to ask whether this community has anything at stake in one model of protein synthesis over another. Whether one is infinitely more "empirical," and, as I will argue later, more amenable to private interests? The dominance of the discourse of gene action is at the expense of more complex models of biological development, yet another suppressed discourse in the history of evolutionary thought.

The rapid developments in genetics over the 1950s and 60s, as well as a reaction against the liberalism and egalitarianism of the social programs and movements of the 1960s, spurned another round of genetic reductionism. This time, however, the selecto-reductionists would go a step further. They would combine the discourse of gene action with a modified Darwinism which would go something like this: Genes play a prominent (or determined, depending on whom you ask) role in shaping human behavior and genes are the primary units of selection, thus genetically determined (conditioned, shaped, influenced, etc., the particular verb doesn't change the basic relation) behaviors-which include much of human social life and behavior-are the result of successful adaptations *encoded on the level of the gene*. Most of these thinkers do not deny the influence of the "environment" or "culture." They make a passing reference to the importance of recognizing these influences and move on. What they miss is that to distinguish between the effects of a gene and an environment in the first place is to already fall into the discourse of gene action trap (Oyama, 1985). The new paradigm took shape with the publication of Harvard entomologist E.O. Wilson's *Sociobiology: The New Synthesis* (1975) and Richard Dawkins' *The Selfish Gene* (1976). Following a huge controversy over the political implications of their work, sociobiology gradually morphed into the more acceptable evolutionary psychology. During this time, however, the reductionist paradigm was being taken up by the growing bio-tech, agro-tech and pharmaceutical industries, used to reap huge profits, and became much more commonly accepted in popular culture as the Reagan years progressed. These dramatic developments in medicine and technology seemed to prove that the reductionists were right all along.

Twentieth century American society needed an origin myth and evolution provided it. This is not to say that evolutionary ideas are not "true" or that they do not reflect much of the "evidence" science has gathered from nature. The question one must ask is this--why did late-nineteenth century scientists accept evolutionary ideas while those in the previous societies in the history of the West had not? After all, there were nascent evolutionary ideas in the writings of some the Greeks, Romans, and others (Bury, 1932). The answer I offer is that evolution in general played a key role in sustaining the bourgeois revolutions of the seventeenth and eighteenth centuries. Again, I want to be careful here and try not to give the impression that I am reducing the complexity or value of evolutionary ideas to "ideology." Evolutionary ideas helped to free biological thought from the rigid formalisms of a theologically-dominated biology, a biology that naturalized the status-quo and denied the possibility of change. Furthermore, many radical political traditions have taken up evolutionary ideas.

However, even within the discourses of evolution themselves, certain choices were made about how to understand the facts of nature. With selectionism, for instance, its most popular versions described selection as a blind force, selecting from chance variations of which humans have little control. Even though it was widely accepted that change can come through adaptation to new environments, these were not environments that humans could create, at least if they expect these changes to carry over to the next generation. Such was the mistake of Lamarck and later the Communists. The same is true of genetics. Against the protests of embryologists, the gene was to be regarded as an autonomous entity, directing development, with only parenthetic asides referencing (and dismissing) its intra and extracellular environments. The success of these models of evolution and genetics is not self-evident. It is what one needs to explain.

The problem was this. How long could liberal democracies last if it gave those less successful in its ranks no hope? Enter Evolution, which was by necessity, against the protests of Darwin and later the architects of the synthesis, a theory of progress. This is why it was so useful in the Anglo-American world. What seemed like the inequities of the Old World, what appeared like the rigid formalisms of caste or rank, were deceptive. The US was in ascent, as were its citizens, all on their way to higher forms of development. What looked like an inequity or formalism was not--if one took history into account. Over the course of history, entities and relations that appeared to be static were actually in a belabored process of change. The logic of adaptationalism replaced formalism. Not to worry, said science, society is in a constant process of change, albeit a very gradual one. And if one's state in the world has not as of yet changed, it is for the best, it is an adaptation to the world as it is. Change cannot come through the agency of people. It comes either randomly (by mutation perhaps) or through adaptations to an environment which humans have no control over. As the century progressed, genetics became a better and better way to frame the lack of "mobility" in the new mobile world of the market economy. The "materiality" of the gene helped to legitimate its importance by allowing it to become an object of scientific study. If one's lot in society did not change, "look"-quite literally--to the only designer of societies we know-not God nor even natural selection (as perhaps we can overcome this with some sort of artificial selection), but the gene. Until the technoscience of the late twentieth century, the gene was the culminate expression of mobile-immobility, a firmly temporal and adaptive entity that could not change.

With the Enlightenment and the subsequent loss of a Judeo-Christian God by which to explain the origin and nature of humans, Western societies turned first to progressive evolution, then to selection and finally to the gene. Western thought has always concerned itself with the question of the development of form and always requires that behind the design lie a designer. As Susan Oyama (1985) wisely puts it,

> Whether it is God, a vitalistic force, or the gene as Nature's agent that is the source of the design of living things and that initiates and directs the unfolding of the design thus matters little to the argument. Nor are the problems inherent in such a notion lessened by the succession of metaphors, such as genetic plans, knowledge and programs, to serve these cognitive and intentional functions (1).

Oyama goes on to explain that this need to find a designer explains why molecular biologists find it so hard to see genetic properties as emerging in development rather than leading it. The discourse of gene action, for Oyama, is simply a modernized preformism-regardless of whether the "design" is initially located in an organism or an "environment." But, the discourse of gene action had to be couched in an adaptationalist logic. So, although everyone believes in change, whether from the "environment" or over the course of evolutionary history, right now the gene is as it is and does what it does. If there is a determinism here, it is in the nature of the gene itself--an autocatalytic, self-contained, agentic entity which communicates uni-directionally with the body. This is simply a fact of nature. The results of genetic processes cannot be "emergent" nor the effects of genes due to "distributed" entities acting in developmental systems-this is simply too close to "soft" inheritance, offering humans the impossible and perhaps even the abominable, an intervention into evolutionary processes. At least, such was the case until recently.

Coda: The Corporatization of the Gene

By the end of the millennium, the context for doing research in the biological sciences in the US changed dramatically from the pre-1970 period. The changes in the organization and economic structure of molecular biology were clearly related to larger political and economic changes resulting from economic and political globalization. While the broader relationship between globalization, education and science will be discussed in a later section, I will briefly detail here its effects on evolutionary thought. I will review its effect on molecular biology as natural selection, per say, remains an a priori which is so uncontroversial it no longer needs to be studied (or even discussed), surviving only as a rhetorical device and a display in museums and textbooks, making inroads for the anti-selectionists and anti-evolutionists who became vocal in the creationist controversies of the eighties and nineties. The most dramatic way these changes affected biology was by turning the Watson-Crick, unidirectional, autocatalytic gene into dogma as well as a source of profit. As public funding of science began to shrivel up in the 1970s and universities looked to private sources for funding, the discourse of gene action flourished, making scientists, doctors, corporate leaders and the "life-sciences" industry (pharmaceutics, bio-tech, agro-tech) more and more successful. Though public money began to return to the life-sciences in the eighties, by then much of biology was already well into the thralls of corporatization.

The revolutions in molecular biology were based in the ideas of the 1950s, but took off via research in gene splicing in the 1970s. The possibility of transplanting DNA from one species to another or "recombinant DNA" was too attractive an idea to private industry for them not to get involved. The major private industry players were the pharmaceutical industry, seeking to develop new medicines, drugs and other health related technology, and the agricultural industry which hoped to genetically engineer crops to increase production and profit. In the early 1970s, the first genetically engineered crop was created in an attempt to make strawberries frost resistant. Human beings had cross-bred crops to improve harvests since the dawn of agricultural societies, but transgenic crop, by actually containing the DNA of another species, can become far more dangerous than the agrotech and biotech industries will generally admit. For instance, Monsanto Company created soybeans designed to be resistant to a herbicide which they also manufactured. Farmers must buy both the seed and herbicide from them. This process is patented under the name Roundup Ready™ technology. Aside from the obvious monopoly Monsanto is creating, the danger is that the long term ecological effects of these new products are not well known and that DNA transplanted from other species will produce allergic reactions in consumers as the US government, caving into the pressure of the industry, has refused to label transgenic agriculture (Lappe and Bailey, 1998). Monsanto Company has also developed crops that are insect-resistant; yet do not require the spraying of pesticides. While this, at first, seems like a positive development, reducing the levels of pesticide in the environment, there is no way of knowing if certain insects will "adapt" to the new crop, modifying evolutionary patterns in ways that might destroy more agriculture than it saves (Lappe and Bailey, 1998). Not to mention, its possible side effect on humans. These crucial decisions about crop and public health are made not by the US government, nor a scientific regulatory body, but by Monsanto.

By the 1990s, the media had become the primary vehicle for the communication and celebration of many of these new technological developments. As private industry looked to universities to find and hire molecular biologists, many worked out arrangements where scientists remained full-time faculty, yet agreed to profit-sharing arrangements with company sponsors, an arrangement encouraged by the Reagan administration in the form of the RDLP (Research Development Limited Partnership), all part of the administration's plan to "deregulate" or privatize anything it could (Krimsky, 1991). While the specter of the Vietnam War had initially discouraged faculty from working with industry and government, the possibility of fame, technological advance and profit was too tempting. Harvard was the first to announce, in 1980, that it would invest in a commercial bio-tech venture. This radically changed the culture of molecular biology as advances had to be kept in secret until they were properly patented and profit secured. In addition, the research agenda for the biological sciences was now being set with the possibility of future profits in mind. Needless to say, these changes in the structure of science would not translate into high school biology curriculum as the fiction of a democratic science free from politics must be taught to the next generation of the consumers of science. The figure of the scientist will remain as "value-neutral" and as free of political or economic motivations as ever.

Critics of the technology argue that by locating, manipulating and finally exploiting genetic resources for economic ends, biotech has turned the gene into "the primary raw resource for future economic activity" (Rifkin, 1998, p.8). There is much evidence for this. The US government has no doubt encouraged it. First, the government quickly began to offer financial incentives to the industry (Krimsky, 1991). The biggest of these was the patent. In 1988, the first higher life form, a cancer-carrying mouse, was patented by Harvard (Haraway, 1997). Over the next decade, this decision would be expanded to allow the patenting of most genetic resources including human genes (e.g. the breast cancer gene is now privately owned).

Bio-tech companies continually search the globe for valuable genes, particularly in populations which have been isolated from the West, often in the products of indigenous medicine, agriculture, even in their very bodies, hoping to patent and profit on a new seed, drug, fruit, gene, and so on (Shiva, 1997). Genetic colonialism has replaced political colonialism as global economic treaties (e.g. NAFTA, GATT) ensure that US patent law is respected by nations across the globe. Currently, US firms like Bristol Myers, Monsanto, Du Pont and others own patents on various plant and animal genes indigenous to the third world. While the old discourses of eugenics have been rejected, the bio-tech industry transforms these discourses by offering gene therapies and the like which will "fix" problem genes. Of course, the definition of "problem" is highly suspect and can include variegated genes from genes that "cause" physiological illnesses to those involved in depression, alcoholism, crime, intelligence, and even poverty. At first the public was not convinced that the promise of bio-tech was worth some of the dangers as well as possible return to eugenics, but the industry along with the university and the State worked hard to convince the public that bio-tech would radically improve the human condition (Krimsky, 1991).

The bio-tech revolution has led to what Jeremy Rifkin calls a "new cosmological narrative about evolution" which is, "compatible with the operating assumptions of the new technologies… [and] provide the legitimizing framework for the Biotech Century by suggesting that the new ways we are reorganizing our economy and society are amplifications of nature's own principles and practices and, therefore, justifiable" (1998, p.9). Rifkin's point is an important one to digest as biotech has begun to change some of the basic notions of what constitutes "nature" and how much intervention humans can have in it. Leading biologists recognize this. As one put it, "As a consequence of recent advances… [biological species] must be viewed… as a depository of genes that are potentially transferable. A species is not merely a hard-bound volume of the library of nature. It is also a loose-leaf book, whose individual pages, the genes, might be available for selective transfer and modification of other species" (cited in Rifkin, 1998, p.35). The arrogance of this position is terrifying. While nineteenth century evolution originally offered a nature that changed over time but could not be affected by human intervention, the twenty-first century brings us a nature that can be transformed by a limited few in private industry who have the economic resources to mobilize these kinds of massive technological interventions. No longer does our hope as a species lie in God or in selection, but instead in the hands of a few large industries and the scientists they employ. Government regulation is no longer relevant as most leading biotech scientists--including those in the NAS (National Academy of Sciences) which advises the US government on science policy (Krimsky, 1991)--are affiliated and supported by the biotech industry. Now "evolution" is to be guided by the needs of capital.

Naturally, the success of these industries depends on a particular model of genetic action. Many in the growing fields of feminist and developmental biology have successfully pointed out that if genes are not the locus of organismic construction, but are only a part of complex developmental systems and pathways, then the kinds of power biotech claims to have to transform human nature in quite limited. This conception of genomics has seeped into the US cultural imagination as DNA becomes, as Dorothy Nelkin and M. Susan Lindee (1985) aptly characterize, a "cultural icon." This icon stands for much. The gene is, "a metaphor, a convenient way to define personhood, identity and relationships… [it is used to] explain health and disease… guilt and responsibility, power and privilege, intellectual or emotional status… [and] used to judge the morality or rightness of social systems" (Nelkin and Lindee, 1985, 16). By making the gene a singular, all-powerful entity, as close to God as we can get in the "secularized" world of the West, the arbitrator of what is good and evil, we offer private industry unparalleled control of the future of human nature and society. After all, the proof of the model is in its technological successes, never mind that we do not know the long term effects of these successes nor that genetic interventions that appear to affect complex systems don't necessarily "cause" change. Genetic intervention perturbs developmental systems, no doubt, but this does not mean it directs them. The idea that so many in the US, including scientists, accept this model of gene action at face value, reveals something about the chilling power of Big Science to mis-shape our very own understandings of our bodies.

Highlights of Argument-IV

Period	Post-Antebellum 1865-1900	Progressive 1900-1917	Cold War 1945-1971	Globalization 1972-2003
Theory of US	Industrialization, growth of poor, create crisis for Protestant Gentry	Immigration, Migration and Urbanization inspire reform movements to "protect" US democracy	American nationalism and economy is strengthened through war with Communism; new social movements	Market and corporate values triumph with deregulation, outsourcing of labor and digitization of knowledge
Instrumental Science	Science is professionalized; marked as technological and modern	Science becomes tool of political and educational reforms; sign of freedom/ democracy	Corporatized, elitist, and militarized science develops	Science is further privatized and used to generate "information"; science no longer promises to be value-neutral
Schooling	Compulsory Schooling requires a modern curricula	Schooling is used to "Americanize" new immigrants and train future workers	Collapse of progressive education; schools must identify potential "geniuses"	Through standards-based reforms schools try and give students the "skills" they need to be competitive; schools increasingly take up the vocabularies of business
Science Education	Entry into US public education	Laboratory becomes important for doing "real" science; science for vocation	Key for success in Cold War; codification in *Sputnik* era curricula reforms; all must "understand" science	Central to national competitiveness; promise of equity and job skills; inquiry-based science standards

Dominant Discourses of Evolution	Contest between selectionism and acquired inheritance	Evolutionary Synthesis: hegemony of gradualism and selection	Central Dogma: unidirectional transmission of genetic information	Genes are privatized and commodified by pharmaceutics, biotech and agro-tech multinationals
Critical Science/Education	nature study; classical, liberal, and broad curriculum	Dewey's vision of education as art and as reflective experience	multiculturalism diversifies schools and science; Lapp, Carson; context of science is recognized as vital	ACT UP and other popular based sciences; Anti-Globalization movements
Critical Science Education/Evolution	Nature Study as means to appreciate the nonhuman world; Lamarckian Socialism	Dewey's vision of science education as reflective experience; revival of Formalism in D'Arcy Thompson	relation of science and technology to society; work on mobility of genes (Mclintock)	curricula linking disease to race and class and/or identifying effects of privatization of science; feminist biology's critiques of discourse of gene action
Educationalization of Science/ Scientization of Education	Science uses education to spread its influence	Education uses science in the form of testing, research and bureaucracy	Science uses education to communicate its importance for the fight against Communism	Standards-reforms create curricula using research and information processing model inherited from cognitive science

Sixth Interlude: Science and The New Global Order

This interlude will introduce the contemporary geo-politics of "globalization" and its relation to the changing structure of US science. Globalization implies several changes in the US economy which correspond to several changes in the US political and cultural landscape. In terms of economics, the seventies were watershed years. In a period of a few years, the US economy had to deal with recession, surging oil prices, "stagflation," the collapse of the Bretton Woods agreement (tying the world's economic development to the US dollar) and by the end of the seventies and early eighties the economic policies of a new generation of free marketers under the Reagan and Thatcher administrations, devoted students of Milton Freidman. In addition to rolling back some of the social programs of the sixties, these administrations sought to increase economic growth through massive military spending--by revitalizing the Cold War wherein the front shifted from South-East Asia to Latin America--and the deregulation of markets.

As David Harvey notes (1990), these transformations were part of an economic restructuring which occurred during the transition from Fordism to post-Fordism or flexible accumulation. While Fordism was characterized by a relatively stable contract between workers and employers as well as a neo-Keynesian economic policy which allowed for state intervention in the economy, particularly through increases in entitlement programs and some protectionist policies, the flexible accumulation model rejected government interference, arguing that prices and wages be set by the market (at least in theory-government could and did interfere in order bail out certain industries). This resulted in the transformation of work with a shift to part-time, benefit-free, service sector jobs as well as international trade agreements (NAFTA, GATT) which allowed multinational corporations to outsource production, labor, etc. so that profits could be increased as the traditional caps on unfettered capital accumulation (labor laws, environmental protection) were undermined. As Harvey characterizes it, "flexible accumulation" reflects the flexibility of labor (both in terms of processes and source), markets, products, patterns of consumption and of course, capital. This "flexibility" also reflects the geographical reorganization of production and the movement of consumer goods and peoples across international boundaries. Although the neo-liberal proponents of globalization employ the rhetoric of fostering democracy--usually in "limited" or "elite-dominated" forms (with the exception of everybody's "freedom to consume")--contemporary globalization is a reflection of the failure of the post-war system's ability to successfully wed democracy and liberalism.

The digitization of financial institutions--allowing capital to move across the globe instantly-and the expansion of the international media are central to this new world economy,[1] reflecting the high value placed on up-to-date "information," leading to the development of what Manuel Castells has called the "network society." This creates a new category of "immaterial" labor whereby knowledge becomes a primary product for export as well as the primary source of productivity--as energy was in the industrial

[1] While capitalism had always been international, the term "globalization" is intended to reference a new *world* economy. In a world economy, capital is flexible. With respect to capital flexibility, the demise of the political power of some nation-states is important, particularly in the so-called developing world which has to rely on supra-governmental, unelected bodies like the World Trade Organization (WTO) and International Monetary Fund (IMF) for direction with respect to economic policy. These economies have become virtual hostages to institutions like the World Bank which lent money to these debt ridden economies—debts which incurred during the Cold War when the West dolled out capital to corrupt regimes in exchange for allegiance against possible communist revolutions—on the condition that they "open" their markets to Western corporations and privatize public resources (e.g. water, energy) which only ends up increasing the gap between rich and poor in these economies.

revolution (Castells, 1996). As Castells describes it, "...informationalism is oriented toward technological development, that is toward the accumulation of knowledge and towards higher levels of complexity in information processing" (17). The pursuit of knowledge/information becomes an end onto itself. While the informational technology revolution was said to hold the promise of the democratization of knowledge (e.g. the internet), this generally was not the case as the means to produce knowledge of value was and is still held by a limited few. Still, the idea that the new economy required new "knowledge skills" will become a powerful rallying cry for the new round of education reforms discussed in the next chapter.

Perhaps the most interesting account of these changes is offered by Antonio Negri and Michael Hardt in *Empire* (2000). By referring to the contemporary politico-economic structure as "Empire," rather than say "imperialism," the authors intend to convey that capital is no longer as interested in the control of territories or establishing a center of power (e.g. the North). As they put it Empire, "...is a *decentered* and *deterritorialzing* apparatus that progressively incorporates the entire global realm within its open, expanding frontiers. Empire manages hybrid identities, flexible hierarchies, and plural exchanges through modulating networks of command" (xii-xiii). I will soon return to the connection between the construction of "hybrid identities," multiculturalism, and cultural postmodernism. Empire no longer depends on the distinctions between East and West, North and South, or First and Third World, as poor "underdeveloped" areas as well as pockets of wealth are now found across the globe. Empire also brings with it a new kind of power: borrowing from Foucault, the authors term it "bio-power." Bio-power is productive-including the production of nature and bodies--as the new politico-financial bodies of Empire produce commodities, markets, subjectivities/identities, modes of communication, even bodies and ecologies. Because of these vast interconnected networks of communication, the new order no longer depend quite so much on the old forms of legitimation-the family, international law, nation-state, even science-but, as Negri and Hardt put it, "rests on nothing outside itself and is reproposed ceaselessly by developing its own languages of self-validation" (33).

Empire has no center. This fact does not preclude the fact that the United States has a very special pace in its constitution. The logic of neo-liberal US Republicanism, as opposed to European forms, has been taken up by these new forms of power including the idea that sovereignty is a product of the people (rather than a force to regulate the people)-though always to be managed by the "people's representatives"-and the importance of expansionism or the constant tendency to include others within its terrain while retaining their difference as well as managing and hierarchizing those differences (e.g. identity politics). Thus, the US occupies the closest thing to a center in the new global order. The idea of the new social movements popping up around the globe in recent years that object to this system is not to somehow "turn back the clock" and return to a pre-globalized or pre-capitalist economy, but to recognize that globalization in its current form reflects the dominance of the market over the people, of liberalism over democracy. This is why so many movements "against" globalization have sprung up around the world in various protests from Seattle to Genoa and often center around Empire's major extra-legal financial institutions (e.g. The World Bank, IMF).

While I can only briefly review the details of these economic and political changes, it is crucial to understand how they play out in US science. Naturally, as I discussed in a previous chapter, the dismantling of the welfare state has increased the burden of funding science from the public to the private sector. This leads to an increased blurring of the distinction between "basic" and "applied" research, pushing some to refer to late twentieth century science as "technoscience" (Latour & Woolgar, 1979). In addition, as a network society requires huge influxes of "information" in order to make decisions-from the boardroom to government and the schoolhouse-the capacity of science to produce "research" has become increasingly valued and institutions from corporations to schools look to universities, partnerships with universities, research institutes, even their own in-house researchers, for crucial knowledge. As this knowledge is more and more valued and commodified, (and in an odd sense, democratized) science adapts itself to these new arrangements by selling knowledge to the highest bidder.

Embattled, the general topography of the scientific enterprise has changed dramatically from its heyday in the 1950s. The large military presence of the Cold War days has been replaced by an even larger corporate presence. As science pursues these new avenues of funding, hordes of ethical dilemmas develop around the independence of the scientific enterprise, even among scientists themselves. Science is, in the words of journalist Daniel S. Greenberg, "only a short way down the path to becoming a toady of corporate power" (2001, p.3). Scientists increasingly sit on the board of directors of large corporations, particularly in the pharmaceutical and bio-tech industries but also in the electronics and aerospace industries, some own shares in these companies and are even themselves venture capitalists. Needless to say, the relentless pursuit of profit in the corporate world has increasingly infected the scientific world. As certain cadres of scientists become wealthy and famous they take on the values of business. For instance, the idea of sharing the results of research in science is fast becoming obsolete as corporations and scientists seek to protect their patents, a trend noted by David Blumenthal in a 1996 study in the *New England Journal of Medicine*. Even those scientists not directly funded by corporations have been affected by the spread of, what Robert Pollack, a biologist and former dean at Columbia University has called a competitive spirit and "a Hobbesian world of each against all" (cited in Greenberg, 2001, p.145). Because contemporary institutions require "information" in order to act, the scientific enterprise has expanded to include many different forms of research institutes and communities, some more and some less affiliated with universities. Another site for this expansion is the field of technocratically-oriented scientific "advisers" (Jasanoff, 1990). The social sciences have also benefited from these expansions as they too can provide industry, government, school systems, hospitals, etc., with much needed information.

During the decade of the 1990s, as it was clear that the Cold War and the government money that it implied was likely gone for good, many nervous scientists set their fears of corrupting science aside and turned to corporate America. The Science Wars, a sensationalist media only happy to expose corruption and failure in science-though ironically less critical about the results of the sciences themselves (Nelkin, 1987)--as well as a general paranoia that the public finds science to be irrelevant-not entirely unfounded-only increased these anxieties. Also adding to the anxiety was the fact that there were fewer jobs for Ph.D.'s graduating from universities. Finally, in the mix, a series of influential books which seemed to argue that the era of major scientific breakthrough was over (Horgan, 1996). Scientists tried to warn the public that cuts in federal spending would be a disaster for the public, but no one seemed to listen. In 1993 the position of scientists was made even more precarious by the cancellation of the multi-billion dollar Superconducting Super Collider.

Clearly, the US government had been pushing science in this direction for well over two decades. In 1980, under the Bayh-Dole Act, universities and research institutes received the right to patent research generated through federal support. In 1987, large corporations were allowed to do the same (Greenberg, 2001). The Reagan and first Bush administrations made federal money available to universities to encourage collaboration with industry. By 1997, almost ten percent of research in universities was supported by industry. Today the figure is much higher. This figure does not include support from non-for-profits and foundations, which are themselves generally supported by corporate funds. In the US, as a whole, 68% of research is financed by industry, but, as one would expect, much of this money is directed towards "development" (Greenberg, 2001). Perhaps not surprisingly, a science consumed with "application" has become more interesting to the general public. The select few who continue to pursue "basic" research, particularly in physics, astronomy and cosmology, produce work that looks much more like "metaphysics" than traditional empirical science (e.g. Smolin, Hawkings, Bohm).

Organizations like the American Association for the Advancement of Science have long been in the business of selling science to the public. During the Cold War, competition with the Russians seemed a legitimate explanation for a national concern about the US scientific enterprise and US science education. Lackluster support for science by the public had generally been attributed to a "lack of public understanding." But, in the post-Cold War era, with scientists increasingly being consumed by the development of potentially profitable commodities, science in collaboration with the mass media have devised new ways of selling science to the public. Who in the public could resist getting excited over the latest "wonder" drug promising to cure cancer or AIDS or the latest in personal computing technology which promises to make our writing ever more efficient? Some critics have referred to these phenomena as "science by press conference." In fact, the press and scientific journals have begun to collaborate to make sure the latest findings of science get proper coverage, a trend even noted by the *Journal of the American Medical Association* (Greenberg, 2001). Sensationalist pieces about the wonders of scientific breakthroughs--usually premature and ultimately retracted--flood "respectable" science sections of newspapers like the *Los Angeles Times, Wall Street Journal* and the *New York Times.* Even reputable scientific journals have joined the bandwagon. When MIT's reputable *Technology Review* shifted its focus from the social and political implications of technology to a chronicle of the latest wonders to emerge from techno-scientific research, its circulation tripled in less than two years (Greenberg, 2001). This is not too mention individual scientists who are only too happy to foist reductive paradigms like the "discourse of gene action" on a naïve public, hoping to secure funding by generating excitement about the promises of genetic therapy.

But, returning to my key argument in this section, if one accepts Negri and Hardt's thesis that the new political-economic order is self-legitimating, what becomes of the legitimating force of the scientific enterprise? Furthermore, how does the new value placed on the products of science/information change the role of science in a neo-liberal economy? First off, the classic problem of demarcation-the idea of distinguishing between science and non-science-is useful only as it ensures that information is "reliable" as opposed to "true." While nineteenth century positivism had long abandoned any notion that scientific facts were true, the transcendental force of science, its legitimating role in the modern world, required that its results be as close to truth as one could hope to get. Today, these transcendental fictions are no longer necessary, hence the success of culturally relative, anti-Enlightenment discourses like postmodernism.

Modeled on the ways in which the market uses information, contemporary institutions, policies and practices easily adapt to the "latest" findings. What is of value, then, is not truth, but capacity for generating results at a particular moment. Thus, if the results of scientific study can be used by the media to increase ratings, by the weatherman to forecast tomorrow's weather or by a lobbyist in Washington to argue the merits of policy, it is all the more valuable. While some scientists still clamor to the beat of old drums, asking about methodology or whether a study could be reproduced, the consumers of science--no longer passive citizens condemned the listen to the voices of expertise--make of the science what they will. Thus, to be relevant, scientists link up and speak the languages of that which is relevant in the contemporary world-the market-and give it what it wants-technology (material or informatic). As science and capital get closer and closer, science no longer speaks with one voice, but voices the many interests it serves. As this becomes more and more obvious, its legitimacy is further usurped, relying only on its real source of value, technology.

Chapter Seven: "Standards" in Science Education

With the transformation of the global economy from the Keynsian/Fordist system of the post-war period to the multi-national, deregulated system developed over the course of the 1970s, 80s and 90s, science moved away from the post-war/Cold War, Big Science model to a new corporatist-privatized and informatics model. There are signs, however, that the legitimating role science has played since the Enlightenment is no longer as vital, as the growth of wealth in the age of globalization appears not to need any obfuscation. Like many other institutions of US society during this period-as is the case with US public education as well-corporate science/education will mean three things (a, b) funding in science and education would increasingly come from industry seeking to turn the results of science in profit-making directions (necessitating a rejection of Bush's basic science paradigm) and the results of education into measurable markers of success and, more importantly, (c) the worth of the scientific and education enterprises would increasingly be judged via the vocabularies and standards of corporate America, standards which are fixated on values like "accountability" and "applicability," as well as the potential for profit. Informatics science works along with this corporatist model and produces "information" to be integrated into institutionalized networks ranging from the stock market to government and policy institutes.

With respect to education, the eighties and nineties brought several consequent movements--a variant of a "back to basics" movement which would eventually turn to mass standardized testing, an end to "social promotion" (rarely providing the necessary economic resources to give poor and minority students the education they need to advance), and finally, a movement to make educational opportunity more equitable including "school choice" programs. By the nineties, many supporters of these movements united under the ambiguous banner of "standards"-a term connoting both a standardization of curricula and assessment as well as a move toward educational equity wherein which all children are guaranteed the same basic education. To be fair, the standards movement is so diverse that it is misleading to lump all supporters of standards under one umbrella. While some are focused on "basics," others are interested in disseminating "best practices" into failing schools and even "whole-school" reform-the idea being that educational opportunity involves more than simply the basics or even instruction. However, I will do a bit of "lumping" in order to make several generalizations about this round of school reforms, particularly, its intimacy with business and privatization as well as its tendency, as other movements of school reform before it, to deskill teachers and homogenize curricula. This time, it will seek to break down the processes of teaching and learning into the minutest of parts so that they can be assessed and reproduced, revitalizing the old distinction between facts and processes. In science, the standards will reconceive Dewey's call for a laboratory-based science. It will try to turn students into "budding" scientists and consequently, obscure the nature of contemporary technoscience, providing a fictitious vision of science that "everyone" can do. Finally, in the standards, one finds the culmination of one of the trends I have been identifying in US education all along--the scientifization of education; in this case, this is reflected by the use of the latest results of educational research to guide educational reform-not a very difficult proposition, I argue, given how much both institutions share with the corporatizing and privatization moves of the neo-liberal age.

1. Education Standards in the Postmodern World

After the tumultuous seventies and the economic restructurings of the eighties along with the re-ignition of the Cold War during the Reagan years, it was not surprising that another crisis in education was to come in which the political winds would shift away from the pluralism and reformism of the seventies and turn "back to basics." Several studies and books began to alert the public as to the crisis, but none more than the 1983 report *A Nation at Risk*, released by the National Commission on Excellence in Education, which sounded the call to arms.

> Our nation is at risk. Our once unchallenged preeminence in commerce, industry, science and technological innovation is being overtaken by competitors around the world... the educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a Nation and a people.

Unlike earlier crises in US education, this one would not have to mask its true source under the mask of "protecting democracy" or "fighting fascism." It all came down to the economy, an economy which was faltering because of the spread of mediocrity in our schools. Never mind that the failing economy of the early eighties was a response to the radical economic restructurings and instability of the seventies and early eighties, nor that the idea of an isolate US economy competing with others was already becoming obsolete, nor finally, that many US standardized tests-by which this mediocrity was detected-are designed to produce mediocrity by being norm-referenced (e.g. grading along a bell curve where the majority, by definition, must be in the middle)-once again US public education was to blame. Also, note that in the quote from the report, "science" is placed alongside industry, commerce and technological innovation, indicating exactly what aspect of science was so important. In fact, the report is littered with ideas that have become widely accepted in education-the goals of excellence and equity, improving teacher training and in-service professional development, precision in curriculum content, rigorous and measurable standards. The report even goes so far as offering some basic standards in English, math, science, social studies, foreign language and computer science.

Over the eighties, the vocabularies of the new educational crisis would develop to explain that in this new age of high-tech and globalization, workers needed more skills, the capacity to "problem solve" and "think critically," and that they were not getting these in schools. In a certain sense the critics were right; as I argued before, the economy had shifted from an industrial to an informatics one where knowledge had become a premier commodity. On the other hand, there were nowhere near enough of such jobs for all graduates of US public education; moreover, most poor and minority graduates would likely end up in low to medium skilled, low paying, service-sector jobs (sans a few tokens). Regardless, as these new calls to transform education in the service of the market grew in number, they were unified under the banner of the standards movement. Because, industry claimed, they needed better workers, they began to take more responsibility for the finding solutions to the crisis. The National Association of Business began to promote school-business partnerships, made even more common given new charter school legislation. Corporate money slowly began to make its way into public schools. Media giant Walter Annenberg famously gave a fifty million dollar grant to fund new schools, some of which would fund the New Visions Schools, a set of alternative public schools in New York City, to be followed a few years later by Bill and Melinda Gates of Microsoft.

Edison Co. and other for-profit schools argued that they should take over "failing" schools around the country while Channel One, an "all news" channel with commercials, popped up in classrooms around the country.

In 1989, President Bush hosted the governors of 49 states at an educational summit intended to create a national system of standards and assessments. Leading the initiative was then governor of Arkansas, Bill Clinton, who agreed to help draft national educational goals. In 1991, the Department of Education awarded several grants to organizations of scholars and teachers, asking them to develop voluntary national standards in science, history, geography, the arts, civics, foreign language and English. Meanwhile the National Council of Teachers of Mathematics had already produced its own set of standards in 1987. The National Council of Teachers of English and International Reading Association published its "English Language Arts" Standards in 1996. National science standards were published by the American Association for the Advancement of Science in 1990 and 1993 as well as by the NRC (National Research Council) and NAP (1996), the latter noted for its focus on teacher and student standards as well as system standards.

The standards movement was a coalition of several different and sometimes politically incongruent groups-some more and some less skeptical of its potentials for substantive reform. In a review of many of the major standards-based curricula (Zemelman, Daniels, Hyde, 1993, p. 5-6), the following common themes were identified.

LESS	MORE
teacher directed instruction	experiential, hands-on, learning
student passivity	active learning
one-way transmission of information from teachers to students	diverse roles for teachers
textbooks	original, whole sources
attempts to "cover" large amounts of material	deep study of less topics
rote memorization and facts	Student's evaluate own work
emphasis on competition and grades	modeling of cooperation and democracy
tracking or grouping students into "ability-based" groupings	heterogeneously grouped classrooms
standardized tests	performance-based assessment

Many of the standards also make reference to the professional development of teachers, suggesting that they needed time together to collaborate on syllabi creation (more so in the case of the standards supported by the teacher unions than "experts" in policy), reflect on their work and build an extensive knowledge base. Similarly, principals were encouraged to become less administratively oriented and authoritarian and more learning-focused, acting as facilitators of their "learning communities." Some of the standards documents were minimal, giving teachers and other local educators much flexibility in the creation of curricula and assessment while others were significantly less so. For instance, the AAAS standards are quite extensive when it comes to "facts," but less so when it comes to laboratory work. These standards documents tend to include content [what student's should know] and performance [how should they demonstrate this knowledge?] standards[1] and some also include opportunity-to-learn standards [do schools

[1] Again, here one finds a core issue related to the scientifization of education. This distinction [performance vs. content] mirrors a distinction in knowledge derived from contemporary cognitive science—that between procedural and declarative knowledge (and of course, process versus fact) (Resnick, 1989). As many intuitive critics of this paradigm in cognitive science have pointed out this distinction is misplaced, as all knowledge is embodied and articulated in practice, making the division between declarative and procedural knowledge senseless. Similarly, recognizing what kids can "do" always involves recognizing what they "know" and vice versa. This problematic distinction allows for a logic that believes that standardized tests,

have the resources to teach the standards?] and professional accountability standards for teachers [what makes a good teacher?]. Most agree that the fundamental ideas of the standards are derivative of the ideas of Dewey at the turn of the century and the school reformers of the 1960s but they contend, unlike in previous generation, this round of reforms is more pragmatic, coherent, and has learned from its mistakes, particularly with its more explicit focus on content and measurability (Zemelmen, Daniels and Hyde, 1993).[2]

As the accountability aspect of Standards became more influential-as is the case of Bush W's "No Child Left Behind" legislation which mandates standardized testing for all grades--rifts have begun to appear in the already fragile coalition. While my focus will be more on those interested in curricular reform, it is crucial not to ignore that this movement takes place in the larger context of calls to accountability, "school choice," and increasing business influence in schools, from the seemingly innocuous--Taco Bell taking over school cafeterias, to the less so--industry-run schools and software company designed curriculum.

Influential educator Debbie Meir (2000), an advocate of progressive education and principal of the Mission Hill School in Boston, charges the standards movement with shifting the locus of authority to outside bodies (i.e. curriculum writers, experts) which

while not perfect, do measure "declarative" knowledge when they are more accurately understood as measuring "declarative" knowledge in the context of a procedure--taking the test.

[2] This is especially true of the *No Child Left Behind Act* which seeks to model federal-sponsored research after the "gold standard" of Big Science research, using "control groups," "random trials" and the like. There is no better recent example of both the scientifization of education and the educationalization of science.

undermines kid's, teacher's and parent's ability to take responsibility for their own ideas, instead deflecting judgment to specially trained experts. Meir is correct, of course, but US public education has been dependent on "experts" (mostly male one's at that) since the turn of the twentieth century and the opening of the teacher training programs. Furthermore, she contends, the focus of the movement has become less on locally-led school reform but on standardization. With more and more high-stakes test forced on kids designed to keep schools and teachers "accountable," as well as the linking of jobs and funding to these tests, teachers must "teach to the test" rather than the standards. Instead, Meir advocates small, decentralized schools where curricula and assessments are negotiated and invented with sensitivity to the uniqueness of a particular school and student body. Even given this growing rift, though, the language of standards continues to dominate contemporary educational discourse.

Many in the standards movement remain stuck in a model of learning from the field of cognitive science which believes that the processes of learning can be broken up into component parts, identified and made explicit to teachers and educators (e.g. Resnick). In this version, learning resembles Fredrick Taylor's scientific management. In the interests of rejecting what they regard as a traditional focus on results, they end up reifying the process in a way that turns teachers and students into machines. Perhaps this should not be surprising as the logic of business has become intimately involved with standards. As Denise Gelberg (1997) points out, the grammar of Standards is adopted from some of the new management models developed by business in this period, particularly one called TQM or Total Quality Management. TQM rejects authoritarian management styles and replaces them with participative ones. Its goal is to produce a service that pleases the customer. Managers become "facilitators" and managers and workers cooperate to come up with fresh ideas and new ways to solve problems. Everyone becomes a "researcher," looking to the data they encounter to help find "fresh solutions." Decisions are decentralized and versatility is valued. All members of the team are evaluated on their performance. Finally, what really drives these new relations is "competition" with other firms, as they must take risks and innovate in order to survive. This model was taken up by corporations across America, from GE to IBM and was widely successful in the technology-based firms in California.

It is not hard to find the basic ideas of the standards movement here-collective construction of standards, education as a service, increased professionalization of teachers, teachers researching their practice, versatility in teaching methods, principals as "facilitators," performance based evaluation and competition via school choice, ideally between small public schools rather than public and private schools. While some might argue that the adoption of business language and ideas is not bad for education, per say, it does constitute a shift in how US culture comes to understand what success in education means-high measurable results (test scores), financial accountability, efficient management, sufficient profit (graduation rates), and skills development (leading to higher economic productivity). While the more "progressive" oriented educators still hold on to Dewey's wish to see education produce a literate, thoughtful citizenry, given the interests involved in this moment one suspects that they are fighting a losing battle.

2. Standard-Based Science Education

The AAAS science standards evolved in the context of a larger project called Project 2061 established in 1985 to reform k-12 education in the natural and social sciences, mathematics and technology. Its goal is to outline, grade by grade, what all students should know and be able to do (content and performance standards) in these area by the time they graduate from high school. The project published several major publications, including *Science for All Americans* (1990), which lays out what one is expected to know in order to be "scientifically literate," *Benchmarks for Scientific Literacy* (1993) which lays out these expectations by grade level and finally *Blue Prints for Reform* (1998), dealing with the implementation of these reforms. Given the context of these standards, one can expect them to try and balance two competing visions of science education: the Big Science version which creates a passive scientific citizenry ready to accept the latest results of science and the corporatized version which emphasizes the skills workers need in the new knowledge economy and seeks to further conflate science and technology, yet another variant of the science-as-fact/science as value problematic. As I hope to show, most scientists still live in educational world designed for Big Science, but the realities of corporate science find there way into the standards, often in ways in which these educators, teachers, corporate leaders and scientists are likely not even aware of. In essence, they will ignore that the scientific vision of the world they project is supported by the context of transnational capitalism and the privatization of science. Perhaps more pointedly, as I will argue, it is dependent on protecting the privatization of both science and education as well as fostering the new pluralisms of neo-liberalism while desperately trying to cling onto its old authority, which is quickly slipping away.

In the introduction to the first report, one is told that, perhaps in contrast to earlier calls to science reform, there is more at stake here than developing an individual's capacity to think and the immediate national interest of the United States.

> The most serious problems that humans face are global: unchecked population growth in many parts of the world, acid rain, the shrinking of tropical rain forests and other great sources of species diversity, the pollution of the environment, disease, social strife, the extreme inequities in the distribution of the earth's wealth, the huge investment of human intellect and scarce resources in preparing for and conducting war, the ominous shadow of nuclear holocaust-the list is long, and it is alarming (AAAS, 1990, p xiii).

One should not be surprised, again, that no specifics will be offered on who exactly is responsible for these things (perhaps humanity in general?), except to say that science can help in solving these problems-again, this refusal to analyze origins, on many levels, is central to instrumental science as well as the standards themselves. And yet, looking closely, one finds likely sites of former struggles now erased by the seamless flow of the document.

> All burning of fossil fuels, unfortunately, dumps into the atmosphere waste produce *that may threaten health and* life (AAAS, 1990, p.115).

> class affects what pressures and opportunities people will experience and therefore affects what paths their lives are likely to take-including schooling, occupation, marriage, and standard of living. *Still, many people live lives very different from the norms of their class* (p.90).

Its not that one must accept all the neo-catastrophic "global warming" scenarios put out by some environmental groups, but its hard to argue that fossil fuels do not endanger human health. One can probably picture the conversations in our own head as some on the AAAS committee argued that evidence for environmental and health damage due to fossil fuels was still "inconclusive" or suggested that saying class "affects" one's life path without any caveats is too "Marxist."

In terms of educational philosophy, the second report (AAAS, 1993) reflects the progressive orientation of the writers. For instance, it eschews too much focus on formal concepts, particularly in the early grades, and is more focused on the way scientific concepts are useful. It offers teachers flexibility in their classes. It frequently requires activity and investigation on the part of the students, though less so as students get older. It recommends that students get regular feedback, memorization of "technical" vocabulary be deemphasized instead emphasizing collaborative learning.

> <u>Grades 3-5 Energy Transformations</u>
> Investing much time in developing formal concepts of energy can wait. The importance of energy, after all, is that it is a *useful* idea. It helps make sense out of a very large number of things that go on in the physical and biological and engineering worlds (83).
>
> Teachers have to decide what constitutes a sufficient understanding of energy and its transformations (82).

> <u>Grades 6-8 Energy Transformations</u>
> Students should trace where energy comes from (and goes next) in examples that involve several different forms of energy along the way (84).

> <u>Grades 9-12 Energy Transformation</u>
> The concepts acquired in the earlier grades should now be extended… (85).

> <u>Grades 3-5 Structure of Matter</u>
> The study of materials should continue and become more systematic and quantitative. Students should design and build objects that require different properties of materials (76).

> <u>Grades 9-12 Structure of Matter</u>
> *Understanding* [my emphasis] the general architecture of the atom and the roles played by the main constituents of the atom in determining the properties of materials now becomes relevant (79).

One aspect of "progressive" education that is easiest to see in these "grade by grade" standards is the shift (very Piagetian in nature) from concepts imbedded-in-activity to concepts-in-the-head. While there are "developmental" reasons for such a shift-the development of so-called formal-operational thought--there is a much more obvious explanation given my prior arguments. The older students get, the more they must be prepared to consume scientific knowledge passively; that is, the more clearly they must be taught that, over the course of their lives, they will *not* be creating the bulk of scientific knowledge they encounter. Real scientists will. Thus, while they should *understand* these concepts, they will no longer be given to resources to create and therefore, challenge these concepts, especially the well established ones. This is the vision of scientific literacy articulated by Big Science which nicely temporalizes the progressive focus on activity and the traditionalist focus on facts. Facts come later in education. Even though there are laboratory activities in the later grades, the results are often set up in advance, leaving the "experimental" nature of the work more like an illustration than experiment. For instance, a study of genetics displays genetic patterns by breeding fungi, studying human genetic disorders, and visiting to hospitals to discuss genetic diseases (Zemelemen, Daniels, Hyde, 1993, p.108-9), but never is the principle of "gene action" itself put to the test.[3]

The NRC curriculum has its own standards-inspired ideas with a particular focus on inquiry. The idea of inquiry is intended to highlight the importance of student-conducted investigations and the conceptual understandings of the natural world students should get through those investigations (NRC, 2000). Inquiry links, "a child wondering how it is possible for ants to live underground to the search by groups of physicists for new atomic particles" (5). This is an important point which helps to demonstrate how the standards will view science-the processes of real science will be completely divorced from their context so that they can be utilized anywhere from laboratories to elementary schools. This kind of abstraction is the point of method in the first place. Further, this kind of abstraction, in this case, the slide from child to physicist, will allow the science standards to focus on method, or "performance," and ignore the concrete political and economic relations which contemporary science is now situated in.

The second crucial issue these standards must take up is the role of science in society at large and the role of science education in that world. Returning to a point I made earlier, the first report (AAAS, 1990) includes the usual reference to a science education which "should help students to develop the understandings and habits of mind they need to become compassionate human beings able to think for themselves..." (xii). Interestingly, the author's add "compassionate" to the ideal capacities of the scientifically literate

[3] Of course, one cannot test the principle of "gene action." My point is only that school science retains the basic dogmas of genetics while giving the illusion of empiricism.

citizen. This is unusual, given the supposed value-neutrality of the scientific method. How can it instill compassion? Perhaps, in the age of postmodernism and globalization, it is no longer necessary to remove all traces of value from the processes of knowledge production as science no longer needs quite the same transcendental justification. Next, the author's hark back to *A Nation at Risk*.

> It should equip them also to participate thoroughly with fellow citizens in building and protecting a society that is open, decent and vital. America's future-its ability to create a truly just society, to sustain its economic vitality, and to remain secure in a world torn by hostilities-depends more than ever on the character and quality of education that the nation provides for all its children (xiii).

The patriotic logic of the Cold War is a bit subdued. America has the "ability" to create a truly just society-though it has no necessarily done so-and needs to "sustain" its economic vitality-which presumably, it already has achieved. Next, comes the line I mentioned earlier, "...there is more at stake, however, than individual self-fulfillment and the immediate national interest of the United States." Here it appears that the "understandings of mind" have been reduced to "self-fulfillment" and "America's future" to "immediate national interest." The authors imply that while these reasons are important, after all, they had explained why science education was crucial for much of the twentieth century, they are not as important as the global political issues listed next-environmental degradation, unequal distribution of wealth, war, etc.

Now, for the key question, how can science help us with this "alarming" list of socio-political problems? The authors continue,

> Science, energetically pursued, can provide humans with the knowledge... needed to develop effective solutions to its global and local problems... By emphasizing and explaining the dependency of livings things on each other... science fosters the kind of *intelligent respect for nature* [my emphases] that should inform decisions

> on the uses of technology… Scientific habits of mind can help people in every walk of life to deal sensibly with problems that involve evidence, quantitative considerations, logical arguments and uncertainty; without the ability to think independently, *citizens are easy prey to dogmatists, flimflam artists, and purveyors of simple solutions to complex problems…* Technological principles… give people a sound basis for assessing the use of new technologies and their implications for the environment and culture… Although many pressing local and global problems have technological origins, technology provides the tools for dealing with such problems… *the life-enhancing potential of science and technology cannot be realized unless the public in general comes to understand science…* without a science-literate population, the outlook for a better world is not promising (AAAS, 1990, p. xiv-xv).

Much of what the AAAS says here is not new. I reviewed the promises of science, the importance of a scientific mind and the perils of a scientifically illiterate society in the curricula of past. Instead I will focus on what is new. If there was a disjunction between how science was described and how science actually was in the days of Big Science, here, it has turned into an all-out chasm. One wonders what science these authors are referring to. Science fosters an "intelligent respect for nature?" Science prevents "flimflam artists" and the purveying of "simple solutions to complex problems?" Technological principles can help overcome the problems brought through technological development? What about technoscience's disrespect for nature as tries to transform it through transgenic crop and other organisms in order to increase production and profit? What about its promise to change human nature through genetic therapy and pharmaceutics? Is this arrogant logic not the ultimate in "flimflam?" Can the pragmatic/profit-oriented logic of technological development really overcome the problems of technology? Isn't the increasing privatization of technoscientific research precisely the problem? It is awfully hard, if not impossible, to bring together the vision of science articulated by the AAAS and twenty-first century technoscience as it really exists. How can science promise to rid us of dogma while some of its proponents provide us with this naïve assessment of science and its promises? Is this anything if not dogmatic? Again, the AAAS tells us, as others have before, that the miraculous promises of science will only come about with better public "understanding" of science, though very little in the report offers students any serious means by which to answer these questions, except, of course, to wait for science to do its work (and perhaps support its fundraising efforts).

Still, there is novelty in the report as well. Science is no longer value-neutral. For instance, "Science, mathematics, and technology incorporate particular values..." (184) and "culturally, science can be viewed as both revolutionary and conservative..." (184)-- Though from the examples the report offers (Newton, Darwin) science appears to be more revolutionary than conservative. In the postmodern era, it appears, one can no longer divorce fact from value, however, one can try to dilute the values in science into ones all can accept like "curiosity" and "openness to new ideas." Informed Skepticism is another one of the values science fosters, except of course, when it comes to the project of science itself. "On balance, science, mathematics, and technology have advanced the quality of human existence, and students *should become thoughtful supporters of them*" (186). At this point the AAAS hints why science education in schools is so vital to them, it is the place (perhaps the last place) where individuals can become "thoughtful" supporters of science. To take this point even further, in a Fordham Foundation review of state-by-state standards, one of the criteria for judging "quality" standards is that "all standards take quite a positive view of science and technology in general" (Lerner, 1998, p.6). Once again schools are turned into salespersons for science.

Thus far, I have focused on much of the science education geared to the Big Science model, that is, one that is geared to turning students into consumers of scientific knowledge. But what about the corporatized model, how does this play into the AAAS standards? One should not be surprised to find, as these standards were written by a science advocacy group, that explicit references to these changes in the nature of science itself are played down, but this does not mean that such references are absent. For instance, the authors dismiss science education reform as part of a concern about America's economic decline or decline in test scores as "utilitarian" and an "immediate justification," though they do admit "there is a strong connection between how well a nation can perform and the existence of high-quality, widely distributed education" (AAAS, 1990, 210). One way we can be assured that corporate interests are taken into account is to look at who exactly is involved in the creation of these reports. Aside from mostly academics, scientists and mathematicians, and a few token teachers, there are representatives from 3M, Honeywell, AT&T, ADC Telecomm, Pillsbury, Texas Instruments, among others. To be fair, they are mostly concentrated on the technology-oriented panels, but, needless to say, it is likely that a great many of the scientists on the other panels have industry connections.

Another change is the importance placed on pointing out the multicultural and relativistic aspects of science.

> The Scientific Enterprise Grades 9-12
> The early Egyptian, Greek, Chinese, Hindu and Arabic cultures are responsible for many scientific and mathematical ideas and technological inventions... People from all cultures now contribute to that [modern science] tradition (19).

> Progress in science... depends heavily on what else is happening in society (19).
>
> Outside their areas of expertise, however, scientists should enjoy no special credibility. And where their own personal, institutional, or community interests are at stake, scientists as a group can be expected to be no less biased than other groups... (19).
>
> Funding influences the direction of science by virtue of the decisions that are made on which research to support (20).

While these statements are not ones we could expect to find in the post-Sputnik curricula, they are not quite as radical as they sound. After all, the "sciences" of the great non-European civilizations of the past are simply reinterpreted as precursors to modern science, with Western conceptions of science reflecting the pinnacle of progress. Scientists are not always objective, the authors recognize, except in their "area of expertise." While told that funding influences the direction of science, no examples are offered. Perhaps recognition of this relatively innocuous "multicultural" and more "humble" vision of science is one the authors willingly accept in order not to deal with the more basic issue of contemporary science-it's increasing role in the generation of corporate profits as well as its role in legitimizing the corporate takeover of both science and public education.

My point is that it is a mistake to look at the content of the AAAS standards to find industry involvement. Perhaps the only site of real corporatism is the increasing use of educational technology in science classrooms, a practice which can involve "activity" on the part of students and is thus very much in line with the standards. However, the key site of self-interest is more likely raising the standing and influence of industry over government policy in general, moving toward a general collapsing of the division between public and private in what was once considered a "public" issue. After all, if it is business that really cares about education, why be afraid of privatizing it? Motivated by "self-interest," they will likely do a better job educating our children/their future workers. Despite the fact that readers are told that "these subjects naturally help to meet future work-force needs and promote U.S. competition" (250), readers are never told how and it is hard to see much evidence for this, given that much of the science standards looks a lot like the laundry list of scientific facts of previous generations, which led to the so-called lack of competitiveness in the first place. Although told that hiring in today's world often involves a check on an applicants reading and math abilities as well as understanding of spatial relations, this is not very common and assumes the existence of some "basic" skills far exceeded by the AAAS standards. In fact, I would argue, from the perspective of neo-liberalism, the role of science education in augmenting economic competition and creating skilled a workforce is deceptive--business interests in these issues is a mask for a more general interest in privatizing the public sphere and further legitimating the logic of business in public policy, as these truly "meet future work-force needs and promote U.S. competition," at least according to business. Take this "value-neutral" position business has recently taken up in its role in education described by the AAAS.

> A difficult issue arises when corporations promote products, ideas or values in public schools. Many people criticize business harshly for using schools to promote idea of free enterprise and to distribute materials reflecting the corporate view on issues such as environmental protection, labor, and energy. *Some businesses recognize this fact and have structured their involvement to address broader goals such as the development of critical thinking skills* (252).

Why does the AAAS defend industry in their science standards? As I have suggested, the fact-driven nature of the AAAS standards, which doesn't really offer much on values, even corporate values, makes the taking up of this "issue" odd. It is true that private industry is "investing" more and more in public schools, but the instilling of business values likely comes more from teachers and school leaders than industry, as I will point to in a moment when I turn to other standards. Instead, what the encroaching role of business in public schools has accomplished is to further legitimate the colonization of the public sphere by the private sector and take for granted that schools should be run more and more like successful businesses. Here the AAAS report (1998) finally comes clean, "Business would participate in scientific reform and assist local schools-*offering expertise in strategic planning and finance* (252). Further, "as one of the countries most powerful lobbies, business can help to create safe policy space for science education reform to flourish, especially in the areas of finance and implementation" (253). The role of business in science education reform, at least according to the AAAS, is not a substantive one when it comes to pedagogy or curriculum, but only in redesigning school administration and finance, giving money and using their power in Washington to precipitate school reform. In exchange for this new role for business, the AAAS is willing to admit that profit-driven, private enterprise has a legitimate role in public education and science education, a far more important victory for US industry than any set of values instilled in schools. Besides, with many school budgets now being linked to performance, the kind of expertise corporations offer will likely increase.

Now, it is easy to see why, for the most part, these standards do not look much different than their 1950s counterparts as the most telling clue about how corporatized science shapes these standards is to see what is not mentioned in these reports. This involves three aspects (a) the connection between the pressing social problems listed in the beginning of the report and the actual standards, (b) the source of these pressing social problems and how science can solve them, and finally, (c) the relation between industries need for a highly-skilled workforce and these standards. In each case, there is not much to mention. There is virtually nothing in the actual content standards that can help people make informed decisions about pollution or the unequal distribution of wealth, except perhaps to wait for scientists to speak ou the matter. Further, there is no trace of any relationship between industry and these problems. Who is degrading the Earth? Can it be companies like Dupont and Exxon-Mobil, the same companies who will now advocate educational reform? How are these companies involved, for instance, in the global spread of poverty? Can "outsourcing" of labor to the third-world be a factor in this? What can science do about this? Aren't these political issues that require mass education and mobilization? Is scientific "documentation" even necessary at this point? Are these companies interesting in helping to sponsor an education that asks these questions? At bottom, shouldn't there be a fundamental tension between profit-driven industry and science on these issues?

It is clear that, as science has recognized the fiscal and cultural threat it is under, it has ignored this tension. Convince educators that we have a role to play in public education, business leaders subtly communicate, and we will allow you to pass off a vision of science that no longer exists, that has likely never existed. Thus, the corporatized science education we find is not one of skills or job creation, though, as I will show in a moment, one will find these aspects in the standards of a less reputable association than the AAAS, but a science that appears to be self-legitimating, but only in a world that no longer exists.

In these cases, pluralistic perspectives are stressed--after all, even industry has a valuable perspective. In fact, isn't industry doing the bulk of scientific research anyway? And as the AAAS warns, don't sources of funding shape the results of scientific research? Apparently, these are questions for which science is not designed to answer. We need never be told who funds science, pollutes the Earth or increases inequalities in the distribution of wealth and resources, but only that because industry has a vital interest in education one can trust them in educational reform.

What is interesting is that standards written by educators tend to be more explicitly adapted to the logic of the new economy, highlighting my point that the values of business come not from scientists--who still live in a world where rationality and the scientific method abound--but from teachers and the educational community, for it is they who feel the pressure of industry (via parents and politicians) to reform science education. Take the Math, Science and Technology Standards published by the New York State Regents (1996). Here, without the help of business leaders, a technology-oriented science education is made far more explicit.

> Standard 2
> Students will access, generate, process and transfer information using appropriate technologies (1996, p.1).

These standards look very little like the "fact-driven" standards of the AAAS. Most of the goals tend to be about the application of math, science and technology rather than basic knowledge of key concepts. These standards even include sections on Engineering. The standards are full of such examples,

> Engineering design is an iterative process involving modeling and optimization finding the best solution within given constraints which is used to develop technological solutions to problems within given constraints (5).
>
> Knowledge and impacts and limitations of information systems is essential to its effective and ethical use (8).
>
> Technology has been the driving force in the evolution of society from an agricultural to an industrial to an information base (38).

This is not to suggest that these standards ignore the scientific method, laboratory activities, or the basic facts of science, it's just that the differences between the AAAS standards and the Regents standards are quite striking when it comes to the instruction on the actual use and construction of technology, particularly information systems (with the NAS standards sitting somewhere in the middle). If one accepts Manuell Castells thesis about the contemporary age being one of informatics, this curriculum makes far more sense, on a practical level, than the AAAS standards designed to offer students, once again, a lot of the "accumulated knowledge" of the scientific community which will not help them "compete." Now, I don't want to imply that I think the role of schooling is to help children get jobs, but I also don't think schools should be communicating a mythic and elitist vision of science either. Thus, unlike some critics of science education (Lemke; Levinson), I do not believe that making school science look more like real science is the solution. Schools need not be in the business of selling science, just like we don't expect them to sell other professions.

Although corporate leaders did not have a direct role in creating these standards, it is likely many will be pleased with this cadre of, at the very best, techno-savvy graduates. Not surprisingly, however, in many poor urban schools, they will be "lucky" to get even this. For those that do, corporate leaders will be pleased that students have become familiar with some of the very important concepts they now like to employ: optimization, finding solutions, strategies, informed consumer decisions, processing information. The list goes on and on. Ironically, but not unexpectedly, is what is missing from these standards-the AAAS focus on multiculturalism and the limits of the scientific enterprise. It's as if by removing the grand claims by which the AAAS vision promises to save the world, technoscience is so humbled it need not be humbled further by admitting its biases or limitations. It need not legitimate itself in the classic terms--neither through the Enlightenment terms as a force fighting the dogmas of religion and convention, nor the progressive terms of making our world better, nor even the post-*Sputnik* terms of making the US more competitive. One is left with a science that needs no legitimation, except that it will help individuals get the skills they need to compete for jobs and still offer a few tokens to the powerful scientific lobby about the value of the scientific method and the importance of the accumulated "facts" which the scientific community has worked so hard to produce.

Thus, hidden in the pages of these standards, one finds another vision of science, one that must rethink the grounds for its own legitimation-though, when the scientists get involved, many appear to have forgotten this. Is science valuable because it teaches us the secrets of nature? Or, because it produces technology which makes our lives better? Or perhaps it gives us the capacity to be skeptical about received wisdom and offers us a method to distinguish knowledge from opinion? Maybe it prepares us for jobs in the new economy? It might just make our country stronger and able to compete globally? If these standards are a bit unclear about which of these are true it is not quite their author's fault. We live in a new world where the old legitimating institutions of the Enlightenment-science, the state, schooling, medicine, the nuclear family, employment, and so on-have begun to lose their force. Today we can finally say what has been true all along. The accumulation of capital is an end onto itself, one we prize highly in the US, no matter what the political, social, ethical and ecological costs. Soon, even science education, as hard as the real scientists will fight it, will have to articulate itself in these terms. Perhaps, in the near future, some will argue that there is no need for science education as classically conceived in schools at all (in fact, this is already the case in some poorer schools), at least if we don't change the terms under which it is conceived

This is not to suggest that critical science classes do not exist in the United States.[4] One critical standards-based lesson I witnessed (in an urban, "low-performing," school) focused on asthma and united the study of the respiratory system with the causes of asthma, particularly the higher incidences of asthma among children from poor communities of color. In the lesson, after the students studied the workings of the lungs, they actually left the building and sought out the causes behind the environmental degradation in these communities. They tried to get the rates of asthma for their community and other communities of color around New York and compare them to national averages and the richer suburbs of New York City. They also studied the

[4] This is one of the problems with lumping, the force of one's point comes through but one misses the subtleties of life. The asthma study I describe is one example of a critical science education but there are other science classes that look at things like the effects of privatization on science, highlight some of the feminist critiques of biology and look to some of the populist science advocacy that arose in the eighties as a response to the AIDS and breast cancer crises (e.g. ACT UP). While these curricular moves are wonderful, they are comparatively rare.

distribution of facilities thought to increase the rate of asthma like chemical and waste-refuse plants. Not surprisingly, they found a higher incidence of asthma in urban areas (as compared to suburbs) and a higher reported presence, in these communities, of pollution-emitting facilities. This politicized take, however, was introduced by this specific teacher and was not something she found in any standards guide. In fact, the teacher consistently complained that she had very little support from her principal and often had to buy some of the materials for the study herself (a common complaint among NYC teachers). The point is, these kinds of critical science education classes require hard work on the part of teachers and are rare.

In general, the science standards further mechanize education. One assessment handbook to help teachers work with the standards offers a litany of things which can be assessed using scaled rubrics (Enger and Yager, 2001).

For Students	For Teachers
A Peer Teaching Rubric A Model Building Rubric Evidence of Scientific Literacy Rubric	Teacher Self Assessment Resources used in class rubric Classroom Interaction Assessment

Many standards guidelines are filled with such content/performance indicators which break down the process of doing (and teaching) science into tiny parts, a derivative of a cognitive science that regards the processes of learning in a similar light. In another instance, The New York Standards Consortium delineates these distinctions between outstanding and competent performances when it comes to the results of a student-performed experiment.

Outstanding	Competent
Number of trials or depth of research is extremely thorough. Uses basic algebraic functions and more than one statistical test for data analysis. Creates graphs and charts which reflect the use of basic algebraic functions and multiple statistical tests. Makes clear and meticulous observations.	Number of trails or depth of research is adequate. Uses basic Algebraic functions for data analysis. Creates graphs and charts which reflect the use of basic algebraic functions. Makes adequate observations.

While it is correct that the point of these rubrics is to make teachers and students aware of what is expected of them, in this case it seems that these high school students are expected to create "doctoral-level" projects. Moreover, what is the difference between "extremely thorough" and "adequate" when it comes to number of trials? Should this really be a concern of students? Doesn't a rubric like this become a cruel joke when implemented in a school without the resources for students to do any "trails" at all? Such rubrics have gone to the other extreme, trying to turn students into professional scientists. My guess is that the author's would argue that this somehow "empowers" students to look at the results of real science and learn to make their own judgments, but how many students will subscribe to *Journal of the American Medial Association* or the *New England Journal of Medicine* and evaluate the science in them? Who would listen to them anyway? Science is precisely designed so that only a small cadre of elites can make these kinds of evaluations. The kind of democratization of science these standards are trying to promote is thoroughly disingenuous, especially since these students must learn to talk the languages of science, and more importantly, within the narrow limits of proper scientific discourse in order to participate in the conversation. These students are taught that, in order to be "critical," they must accept the basic principles of the scientific enterprise. Put more directly, in order to be "skeptical" they must begin with accepting some basic dogma about science.

It is evident that that there is a "developmental" trajectory to these kinds of standards. They generally begin with interesting, fun activities which have little to do with "science" in any rigorous sense and gradually become obsessed with facts and turning students into real scientists, even though we all know, no serious scientist would ever take their work seriously. Unless, of course, they actually become scientists, once again, turning schools into recruiters for science-which now increasingly means recruiters for industry. The truth is, most of these students are not likely to be scientists and the realities of corporate science look nothing like this. Even the focus on "process" in the younger grades is not quite what it pretends to be-there frequently is a "right" process and a "wrong" process, no matter if the results are the same, a phenomena noted by Valerie Walkerdine (1988) in her study of the mathematics reform. Ironically, the less the inquiry looks like "real" laboratory science (e.g. the asthma study I described earlier) the more exciting and critical it can be. The more it can truly democratize the production of knowledge!

There are some more troubling aspects of these new standards reforms, especially as they play out with respect to race and class. Take the US Department of Educations "NAEP" Data, a self-described "report card" for US schools. While I don't want to make too much of these kinds of large scale surveys, they can, when not taken too seriously, offer an interesting glimpse at what is happening in US education. The NAEP data for 12th grade science gives students a standardized, norm-referenced exam in science as well as asks them, their teachers and schools a series of questions about what is happening in their classrooms. It is often used to link teaching practice to student achievement, but if one looks at the data carefully, one finds a key contradiction in the reality of standards in a market-oriented world. The tests are traditional markers of achievement, they measure facts.[5] Thus, naturally, they are not standards-based. It is only in the questions to the teachers and students, that one can find out how many schools, out of those surveyed, claim to follow a standards-based science education.[6] Take the following question from the 2000 NAEP data:

> About how often do you do each of the following in your class? Carry out the science experiment or investigation you designed (student-reported).

Needless to say, this should be at the heart of a standards-based science lesson. 49% of students reported that they never had and 67% had done so less than once a month. Yet when one correlates those responses with actual scores on the tests, one finds that the difference between the scores of those who have never done an investigation and those who have done so 1-2 times a month (the more frequent response) are non-existent. In

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[5] Examples of the type of questions on NAEP include:

1. Scientists estimate that the Earth is about how many years old.
    a. 100 billion years old
    b. 5 billion years old
    c. 60 million years old
    d. 1 million years old
    e. 10 thousand years old

2. Which of the following statements about scientific knowledge is correct?
    a. It is based on observations and experiments that can be repeated by scientists
    b. It cannot be tested
    c. It is based on laws that never change
    d. It is based on faith and belief.

While the "correct" answer for #2 is "a," it is not hard to make the argument for "b" and "d" (source Enger and Yager, 2001).

[6] The practice-question sections of NAEP also have attitude assessments which ask students to rate how they agree with questions like "science classes are fun" and "All people can do and practice basic science" (Enger and Yager, 2001).

2002, as funding and success are more and more linked to these kinds of high stakes tests, it begs the question, why teach standards at all?

One more result of the NAEP data which is even more disturbing. When one looks at the question, "About how often do you do each of the following in your class? Write up the results of the science experiments or investigation you designed (student-reported)," again a standards staple, one finds a similar relation between practice and achievement. Oddly the students who do best are those that write reports less than once a month and not those who say that they write reports 1-2 times a month. It seems that a little report-writing is good, too much can be detrimental to one's scores. When one breaks down the results by race, the results are striking. Black students report to be writing up the results of their investigations far more than white students (12% as compared to 9%), yet do far worse on the exams. On their own, both these "facts" are not surprising. Schools in minority neighborhoods have been a major target for standards-based reform and black kids tend to do worse on standardized tests, on average, than white ones. But, when we put these two facts together, the NAEP data suggest the possibility that by not doing as much standards-based science, white kids might be better prepared to take these all important tests. This is far removed from the standard's professed goal of excellence and equity. It seems possible that the standards, no matter how much it wishes it were otherwise, stubbornly reproduce the inequities of US society.

At its best, some incarnations of the standards can get students into their communities, asking questions and finding answers to vital problems a community might be facing and not know how to tackle-but is this science or good old fashioned muckraking? Does it really matter? It is true that some of this is what Dewey had in mind when he wrote about science education, but this was before science became Science, the premier knowledge-legitimating institution in the West. It is not the job of schools to uncritically reproduce the dogmas about the power and wonders of science and/or technology. It is the job of school to get students to think critically: to ask what we take-for-granted when we put our faith in "science," believing that science can produce higher-order, value-free knowledge especially as it becomes increasingly privatized. School science fails when we fall short of getting students to ask in whose interests these differing visions of science serve in the first place. In many ways the paradigm of "nature study" or what we today call "inquiry" is a wonderful model for education. When done well, it can be stimulating, informative and a great way to teach kids. The problem comes when we conflate these variegated ways of engaging and learning about the world with Science-a phantasm claiming to transcend the everyday via its special methods and create a slew of experts who end up, in one form or another, "protecting" liberalism from democracy, even more so because science itself has moved so far from this in actual practice. Isn't it time we began a serious debate about why we teach science in schools in the first place? Isn't it time we stopped justifying our educational reforms through the vocabularies and "tests" of science? Isn't it time we asked ourselves whether the original promise of science-to interrogate convention and dogma, to democratize knowledge production, to create a better world, and so on, has already long failed? And, if this is the case, just what exactly should be the role of the scientific enterprise and science education in our society?

Finale: A Clash of Fundamentalisms

Alongside the new political and economic configurations I discussed previously came two divergent cultural responses, postmodernism[1] and a resurgence of religious fundamentalism, which again, dramatically affected debates over science and educational curricula by the end of the millennium. These are the subjects of this final interlude, specifically the ways in which these new "cultural logics" shape the discourses of natural history. While critics tend two see these as oppositional phenomena, the first "progressive" and the latter "traditional," the case, as I will point out, is far more complex. While seemingly not directly connected to the last chapter, the fundamentalist controversy over the teaching of creationism has much to say about the state of US science, US education and science education. If I am correct in my supposition that the implicit bargain science has made with the new neo-liberal order is that all will ignore just how dependent science has become on private capital and science will limit its claims and accept the value of "multiple" perspectives, then why wouldn't the anti-evolutionists take this opportunity to demand equal time for their version of the history of life? And this is just what they did. Many "equal time" movements sprouted up around the country, but I will focus now on two of their more well-known, if short-lived victories. In this

[1] The "cultural logic" of these new economies is the seemingly anti-enlightenment discourse of postmodernism. Against the "metanarratives" of progress, science, enlightenment and development or modernity, postmodernism looks to the values of complexity, contradiction, heterogeneity, local knowledge and ephemerality in order to explain the world. Ignoring the fact the many of these values were the cornerstone of the modernist movement of the late nineteenth and early twentieth centuries (recall Baudelaire's homology between the modern and the ephemeral), these ideas have once again returned to challenge the Enlightenment's fetishization of rationality, science, coherence and so forth—put more broadly, a seemingly anthropomorphized and totalizing view of the universe. However, postmodernism is not quite the radical break from, or critique of, modernity it purports to be. It is, in many ways, the cultural logic of globalization. Even if it does not always means to do so, it articulates a kind of conservatism which aids the processes by which capital is globalized and deregulated. It rejects the transcendental side of Enlightenment values and seeks to locate them in particular historical and political contexts. However, in postmodernism's rejection of transcendentality, it often ignores its own historical origins, creating its own "metanarrative" about its lack of grounding in modernity itself.

battle over the teaching of evolution, one finds some of the foundational relations of contemporary science-the tension between immanence and transcendence, fact and process, and instrumentality and truth.

In August 1999, the Kansas State Board of Education decided to delete almost all mention of macroevolution from the state's science standards and opened the door for the offering of creationism as an equally plausible theory of the origins of the universe, opting that the decision be made by local school boards. This act opened a national debate on the relationship between science and religion as well as nicely illustrates some of the basic contradictions and complexities of contemporary school science. Many well-known American science personalities including Harvard's Stephen J. Gould and public televisions Bill Nye have criticized the decision and charged the Kansas Board of Education with tainting science education by introducing religion into science classrooms and fear that other school districts will take similar steps. Against this, supporters of the Kansas decision like then Texas Governor, and now President, George W. Bush argued that it is important to offer children different versions of how the world began, including the biblical one. His then Democratic rival, former Vice President Al Gore, agreed. Though the decision was ultimately reversed in 2002, the controversy shows no signs of abating with local school boards across the country battling over whether creationism belongs in science class.

What makes this controversy especially interesting is that supporters of creationism introduced the kinds of arguments that scientists would usually make to defend their position. For instance, Jay Nicholson described the revised Kansas standards (sans evolution) as doing "a very good job of encouraging critical thinking and examination of data" (New York Times, 12/12/99) because it allows teachers to question the theory of evolution itself. Sounding like a good Popperian, Linda Holloway, the president of the state board of education said "the heavy emphasis [on evolutionary theory] implied the evolution was beyond examination." Ms. Holloway recognized that this was not how good science should be. Former Republican state chairmen Steve Abrams weighed in. "It is not good science to teach evolution as a fact" (NYT, 12/12/99). Taking empiricism seriously, an Alabama biology textbook reported, "no one was present when life first appeared on Earth. Therefore any statement about life's origins should be considered as theory, not fact" (NYT, 12/12/99). The "liberal" and "tolerant" perspective usually expressed by scientists is nicely represented by Lu Bitter, co-chair of the high school science department in Pratt, Kansas. She covers all views in the classroom and when students leave "they know that there are different ways of looking at the way life exists on earth" (Education Week, 9/99).

In contrast, mainstream scientists and others who were mostly critical of the decision often sounded dogmatic and anti-empirical in their criticisms. One biologist argued that because evolution was such a unifying theory of biology, students would be unprepared for college admission tests and college biology courses. Thus, its prominent place in tests and in our culture makes the theory of evolution a necessary part of a school science curriculum. Kansas state Representative David Atkins insisted that the creationists have a right to be heard, but not in science classrooms. He added, "Would people with these concerns really feel comfortable with a public school teacher talking about these kinds of things? Wouldn't they be more comfortable with a faith leader?" (Education Week, 9/99). Atkins suggests that people's level of "comfort" should dictate what be included in science class. What about those not "comfortable" with the idea of evolution? Agreeing with Atkins, the Republican governor of Kansas described the board (presumably in contrast to the scientists) as promoting a political philosophy which has no place in education. Finally, a major peddler of neo-Darwinian evolution, the NCSE (National Center for Science Education), which lists as its supporters Stephen J. Gould and Dorothy Nelkin, among other well-known scientists, published a list of the "25 Ways to Support Evolution Education" which included "thank[ing] radio and television stations for including programming about evolution and other science topics" and "give[ing] gift subscriptions of *Reports of NCSE* to friends, colleagues, and libraries" as well as encouraging scientists to share their knowledge with K-12 teachers. This seems far removed from the "interest free" attitude scientists are supposed to take.

What exactly is going on here? Why are the so-called "religious fundamentalists" pushing open-minded inquiry and supporters of science arguing that the conventional nature of a theory makes it unquestionable? This is not to suggest that creationism should be taught in schools, nor that it is correct to consider evolution a "theory" in the Popperian sense (it is more like competing, often contradictory, configurations of theories, facts, practices, and frameworks), nor that the creationists are honest about their interest in "open-minded inquiry," but that the answers to these questions help to understand some of the contradictions essential to contemporary school science and science in general which I have been pointing to over the course of this thesis. To begin with, my way of stating the problem is a bit misleading. Since at the least the mid-60s and the subsequent popularization of the works of Norwood Hanson and Thomas Kuhn, most thoughtful scientists would recognize the importance of convention in scientific knowledge. Even Karl Popper recognized that scientists do not discover "truth" in any obvious sense. At most they get at it in a negative sense, getting rid of more and more errors. His influential distinction between the context of discovery and the context of justification allowed for the idea that the selection of scientific problems and even the generation of scientific theories were influenced by cultural forces. For Popper this was not the case with the context of justification, but both Hanson and Kuhn, in their own way, questioned this. The point is, scientists long ago recognized that their theories were not "true" in any more than a contingent sense and that they always had to be open to revision. What makes science special, then, is precisely not its content but its methods.

Rather than the discoverers of "truth," most practicing scientists recognize themselves to be problem-solvers, using methods, machines, algorithms, etc., to figure out what works and what doesn't. A classic illustration of this, as illustrated in a previous chapter, was Watson's autobiographical *The Double Helix* which described all the tinkering with machines he and Crick had to do to "discover" the structure of DNA. Another is Bruno Latour and Steven Woolgar's classic study of science-in-practice, *Laboratory Life* (1979). Essentially, these methods are a variant of American Pragmatism--it is true because it works. It becomes false when it stops working. Modern science is, in this sense, essentially instrumental, viewing true knowledge as an instrument used to successfully reach certain ends. For instance, one science educator argues that while "traditional" research had been organized around a theory to be tested, contemporary research "is strategic, or targeted toward a problem to be solved, such as efforts to control the AIDS pandemic" (Education Week, 11/99).

The problem is that contemporary science is more complicated than that. It is, as Bruno Latour would characterize it, janus-faced. On one hand it says its results are contingent, its truths are in its methods and it is interested in what works rather then in some transcendental truth. On the other hand, the financing and publicizing of science requires that people take what scientists have to say very seriously. If scientific theories, or worse scientific facts, are culturally determined or only temporary solutions to problems which could be proven wrong at any time, why give scientists so much money and respect. In other words, in order for it to have become the dominant mode of knowledge in the West, which it surely has, it must occupy the place once occupied by religion, the preeminent producer of "truth." Thus, while scientists never argue that they discover "truth," they do act like a version of the kind of truth found in the bible or revelation is inherent in their methods rather than in a particular piece of knowledge. The instrumentality of science, then, is a cloak for transcendence. They have, therefore, more in common with the creationists than one might think.

Thus, scientists find themselves in a difficult position. On one hand, they recognize that there are many conventional aspects to the theories of evolution, aspects that cannot necessarily be proven wrong. On the other hand, if evolution has dogmatic or unfalsifiable elements, elements that are not therefore truly "scientific" in the Popperian sense, why not allow other groups to offer their own alternatives. Creationists offer their own unfalsifiable propositions which many people already accept. But, a scientist might argue, in contrast to creationism, they have accumulated much "evidence" for evolution. This point misses that the "evidence" only makes sense when read through the theory. Ignoring this tautology, scientists want it all. They want their theories (or more precisely in the case of evolution, unifying frameworks) to remain special (i.e. different than creationism) even if they are not necessarily "scientific" in their own sense of the term. Further, they argue their knowledge is even more special because, in contrast to religious knowledge, their results are practical. Yet, at the same time, they have access to nature as it exists in-itself; this is what made them special in the first place. If this is the case, then how practical can their knowledge be as it only reflects nature. They can hardly deny the conventionality of knowledge, at least aspects of knowledge, yet they want to be funded and listened to as if their knowledge transcended culture. These contradictions are at the heart of contemporary technoscience and easily find their way into schools. There is no question that creationists are exploiting these contradictions, but they were undoubtedly there for them to exploit. Given the privilege accorded to science in the current historical moment, who can blame them. Science is the only game in town.

Many creationists have recognized this problem since the days of William Jennings Bryan. Bryan's contemporary, George Edward Price, a Seventh-day Adventist, developed his own version of the origins of the universe which rejected gradualism and returned to the idea of a great deluge. With Bryan's victory and the new references to evolution in textbooks as a "theory" rather than "fact," anti-evolutionists were satisfied. Then came three events which changed everything: influential Evangelicalist Bernard Ramm's *The Christian View of Science and Scripture* which went the furthest in reconciling creationism to the emergent evolutionary synthesis, the BSCS curricula which reinstituted evolutionary ideas into the canon of modern biology education and the 1968 Supreme Court decision striking down an Arkansas anti-evolution statute under the anti-establishment clause. In reply, John C. Whitcomb Jr. and Henry M. Morris published *The Genesis Flood*, another and probably the most influential revival of catastrophism to this day. In fact, one of the leading debates in creation science has become whether one must speak of a great flood in order to remain true to the creationist position (Numbers, 1992). While many scientists including Evangelicals challenged the science in *The Genesis Flood*, the authors insisted "the real issue is not the correctness of the interpretations of various details of geological data, but simply what God has revealed in His Word concerning these matters" (cited in Numbers, 1992, p. 207). As more and more evangelicals accepted the Ramm (and his ASA-American Scientific Affiliation, a theologically oriented science organization) thesis, the Creation Research Society came into existence in 1963 to oppose it, made up of almost all professional scientists, seeking to unify the account of creation in the bible (including a great flood) and scientific evidence. To stem the influence of the BCSC curricula, they developed their own textbook for high schools. Gradually the group began to refer to their ideas as "Scientific Creationism" or "Creation Science" and, more recently, "Intelligent Design" and sought to place creationist science on par with, rather than in the stead of evolution as a plausible explanation of the origins of life. This became known as the "two model-approach"

(Numbers, 1992). With the rising tide of religious conservatism in the 1970s, a reaction to several "anti-religious" Supreme Court decisions, the cultural radicalism of the 1960s, and newly elected president Ronald Reagan referring to evolution as a "theory only," the stage was set for another showdown, this time in Little Rock, Arkansas.

In 1981, an Arkansas statute accepted the two-model or "balanced treatment" approach for the teaching of biology in schools. To make the case, creationists referred to Karl Popper's reference to evolution as a "metaphysical research programme" (as its major theses could not be falsified). The scientific community, recognizing what was at stake, responded by bringing out their big guns to testify against the new "balanced" laws at the trial challenging the statute. The challenge was brought by, once again, the ACLU, and included leading philosophers and scientists like Michael Ruse, Dorothy Nelkin, Stephen J. Gould and others who, although had very different ideas on what the processes of evolution actually were, were united in their rejection of creationism. They later responded with *Science and Creationism* which sought to teach the public how to distinguish between the provisional and testable claims of scientists and the unsubstantiated claims of creationists. Because creationists had now begun to describe their work as an alternative science rather than simply a religious perspective, they began to win similar battles in many states. In poll after poll, the general public supported the two-model approach. In fact, a 1981 Associated Press-NBC News poll showed 83% of Americans favored having creationism taught in schools (Larson, 1985). Thus, the controversy could no longer be described as "science vs. religion"-though the opponents of creationism would do just that--but more correctly elitist expertise vs. populism

(Numbers, 1992). Less than ten months after it was passed, the statute was struck down because creation science, the US District Court ruled, did not take data and weigh it against opposing data, thus did not meet the criteria for "real" science. But, as I pointed out time and time again, by this criterion, many evolutionary ideas are not much of a science either!

In the mid-1980s, Stanley Weinberg, a high school biology teacher, helped to create the National Center for Science Education (NCSE) to battle creationism in schools. In 1984, the NAS published *Science and Creationism: A View from the National Academy of Sciences*, sending out over forty thousand copies to schools and teachers, which explained just what was at stake.

> In a nation whose people depend on scientific progress for their health, economic gains and national security, it is of utmost importance that our students understand science as a system of study, so that by building on past achievements they can maintain the pace of scientific progress and ensure the continued emergence of results that can benefit mankind (cited in Numbers, 1992, p.321).

The rest of the pamphlet explained how the teaching of creationism threatened this, possibly returning us to the "dark ages" and destroying the very fabric of the modern world. Notice just how high the stakes were for the NAS.

The *Science and Creationism* volume was the first in a serious of books by scientists to defend what they regarded as illegitimate claims to scientificity, claims which could only be made through the criteria scientists had already established. Others included *Science on Trial* (1982) by Douglas Futuyama, Richard Dawkin's *The Blind Watchmaker,* Daniel Dennet's *Darwin's Dangerous Idea*, and the seemingly more sympathetic, *But is it*

Science? (1996) edited by Michael Ruse. Futuyma's book is an explicit, all-out polemic against the idea of creation science. The book's opening chapter "Reason Under Fire" sets the tone for the entire book. Creationists are trying to turn back the clock, rejecting science and replacing it with religious dogma. Here is a case in point.

> It is difficult to believe that in the last decades of the twentieth century, when we have sent spacecraft past Saturn, discovered the forces that move continents and life mountains, traced the biochemical pathways of the cell, and revealed the molecular structure of the gene, *science should still be at war with medieval theology.* But religious orthodoxy, while it has retreated before physics and chemistry, has still not come to terms with biology... *[Science] is under more serious attack now than it has been for half a century. The threat is not trivial* (4).

Futuyama is correct; science is in trouble, but not from the threat of religious fundamentalism. The danger to science has always been from within, from its own, so to speak, fundamentalism. The rest of the book consists of a detailed debunking of creationism and explanations of evolutionary theory, resting on the assumption that ultimately, when it comes to explaining nature, one must choose between science and religion, reason and dogma, and, to no one's surprise, Futuyama's offers mounds and mounds of "evidence" about in which position reason lies. Ironically, Futuyama accuses creationists of a "black-or-white, all-or-none" (20) view of the world, but his view is not so different. Creationists are successful, Futuyama argues, because their explanation "makes few demands on its audience's intellect" (21) and scientists are too busy to "commit themselves to public education and public debate" (20). Perhaps, one should ask, is there a more complicated explanation for creationism's appeal? Ruse's book is a bit more generous to the creationist position, allowing its audience to see that there are legitimate debates about orthodox Darwinism in biology itself-arguments about gradualism for instance, one's that creationists themselves often employ. It offers voices sympathetic to creationism a pulpit, and even admits that distinguishing science from nonscience is not so simple. And still, the book lets us know in advance what the central problematic of the book is, "the battle between science and religion is not over" (5).

The creationist position has fought back with its own literature. Beginning with Duane Gish's bestselling, *Evolution: The Fossils Say No!* (1972), anti-evolutionists and anti-Darwinians have released their own volume of works which point out the holes in evolutionary theory and Darwinist orthodoxy and make the case for the sensibility of Intelligent Design (ID). One example, *Shattering the Myths of Darwinism* (Milton, 1992), argues that evolutionists themselves have failed to make a convincing, evidentiary-based case for Darwinism. Milton makes clear that his objections are not religious but scientific. He offers several famous examples where Darwinism appears to fail-doubts raised about a correct estimation as to the age of the Earth, the difficulties of reconciling the theory of plate tectonics and gradualism, the general critique of uniformitariansim, especially as related to the fossil record, the unlikelihood that infinitesimal variations can "add up" to larger changes (e.g. the famous argument about the complexity of the human eye), the idea that aggressive competition is necessarily beneficial to a species, among many other objections. Many of these objections are also raised by Stephen J. Gould in his *The Structure of Evolutionary Theory* (2002), though he regards his position as an "addendum" to Darwinism while Milton believes that it is only the intellectual authoritarianism of leading evolutionists that keep Darwinism alive. Perhaps Gould realized that to reject Darwinism altogether would have alienated him from the "scientific establishment" in ways he was not prepared for. Michael Denton's *Evolution: A Theory* *in Crisis* (1985) makes a similar case, referring to evolution as satisfying a "deep psychological need for an all embracing explanation for the origin of the world which has motivated cosmogenic myths of the past" (358). For Denton, the origin of the species still remains mostly a mystery. Similarly, Philip Johnson's *Darwin on Trial* refers to Darwinism as "pseudoscience" and the author is noted for his belief in "Intelligent Design," which doesn't necessarily assume the existence of a God. To be fair to critics of these positions, most of these authors almost always conflate evolution and Darwinism and are never really clear about whether they believe biological forms change in time, perhaps the more fundamental aspect of evolutionary thought and the one that is most difficult to reject.

What these authors have in common is not that they necessarily advocate a creationist perspective-which, as an aside, generally tends to be a diverse as evolutionary one's-but that they convincingly make the case that science knows far less about the origin of life than it claims and that its claims are often non-scientific, especially in its own terms. While there is no question that some attacks on Darwinism can cleverly, and not so cleverly, hide a biblical perspective in scientific rhetoric, the same can be said for the kind of theistic evolution long held by many scientists. There is no easy solution to this question. On one hand, the argument made by proponents of ID, that life is too complex to have evolved by chance, is a good one, but might say more about the nature of self-organizing or autopoetic systems than whether natural selection is an importance mechanism for change (Maturana and Varela, 1987; Oyama, 2000). On the other hand, it is hard to object to these and other critics when they recognize that evolution, or at least

Darwinism, like the enterprise of science itself, has become dogma. If these authors make a mistake, it is to conflate Darwinism with evolution in general, but evolution without Darwin is only the basic idea that life, including form, has changed over time. Writing in *The New York Review of Books*, Richard Lewontin explains that he accepts the basics of evolutionism because "we [scientists] have a prior commitment, a commitment to materialism" (1/9/97). He agrees that this commitment is not based in science but recognizes that one must accept it if one is to accept the fundamentals of the scientific enterprise. But why must we accept materialism? What kind of world would we live in, one wonders, if we could really say "we don't know?" Why should we be forced to accept that satisfying explanations can only involve so-called "natural"-perhaps a synonym for "understandable by humans"-forces?

What many of the defenders of evolution miss is a broader and contextualized understanding of religious fundamentalism as well as, of course, their own fundamentalisms. Like postmodernism, religious fundamentalism positions itself against the project (or arrogance) or modernity. But also like postmodernism, it too is part of the logic of globalization. Religious fundamentalists who seek to turn back the clock and return to a fictitious age of morality, wholesomeness and purity base their movement on a series of fictions.

> The "traditional family" that serves as their ideological foundation is merely a pastiche of values and practices that derives more from television programs than from any real historical experiences within the institution of the family. It is a fictional image projected on the past, like Main Street U.S.A. at Disneyland, constructed retrospectively through the lens of anxieties and fears (Hardt and Negri, 2000, 148).

This phantasmic image is constructed by various capital-friendly forces ranging from the media to advertisers and politicians. This kind of cultural fundamentalism easily adapts to the contemporary world, as evidenced by the relation in the US between the religious right and the pro-business elements of the Republican Party. It is, no doubt, a protest against the contemporary order, as it, in some forms, refuses to take on the central tenets of neo-liberalism and collectively mobilizes people by holding on to some form of permanence or meaning in a world increasingly characterized by the mobile and fleeting. However, its critique is misplaced, again focused on the cultural values modernity which the new order is not especially invested in anyway. One find similar dynamics with Islamic Fundamentalism, but here there is a more direct threat, at least on the grass-roots level, to the neo-liberal order. It too shares a similarity with postmodernism as it rejects the logic of modernity and the Western dominated order it implies. Unlike most postmodernisms and other religious fundamentalisms, however, it has not made peace with globalization as evidenced by the growing Anti-Western sentiments in the Islamic world. As Hardt and Negri perceptively note, one might argue that "postmodernist discourses appeal primarily to the winners in the process of globalization and fundamentalist discourses to the losers" (150). This logic might explain why Western postmodernism is far less threatening to the global order than Islamic Fundamentalism and why the West has been in the process of creating its own *Jihad* against the Islamic world since the fall of the Soviet Union-perhaps the last great challenge to neo-liberalism. The Iranian revolution put the fear of Islam in the hearts of Western capital. The process was stepped up with the demonization of former US hack Saddam Hussein-who committed many of his "crimes against humanity" while he was still an ally of the US with the weapons supplied to him by the US in the Iraq-Iran War. These ideas coalesced in Michael Harrington's bestselling *The Clash of Civilizations* and the battle intensified after the tragedies of 9/11.

The point is, however, that fundamentalism is a protest against modernity that is constructed through the logic of modernity. Most religious fundamentalisms miss that the source of their woes is the politico-economic order they have come to terms with rather than the cultural order they reject. Even orthodox Islamicists too often conflate the cultural with the politico-economic as reflected by their desire to turn secularized Arab states into Islamic ones with scant attention to what that would mean on an economic level-often assuming that by following the word of the Koran, social inequity would take care of itself, though some Islamic groups (i.e. Hamas) are very involved in delivering social services to their communities (Ali, 2002).[2]

But is not the distinction between globalization and fundamentalism itself too simple, as was the case with the distinction between science and fundamentalism? In other words, aren't these advocates of the neo-liberal order equally "fundamentalist" when it comes to their faith in the market? This is precisely Tariq Ali's point in his aptly titled *The Clash of Fundamentalisms* (2002). It is not hard to see the connections between the American exceptionalisms of our earlier history (e.g. Manifest Destiny, US postwar policy) and the

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[2] The post 9/11/01 logic seems to suggest that religious fundamentalism is a greater threat than ever before. I would argue that this is incorrect. The events of 9/11 are better viewed as a desperate, late attempt by those outside the West to deal with the worldwide dominance of Western forms of globalization. The widespread "condemnation" and "horror" at these events, as well as, for a while, the relatively unchallenged moral authority it gave the US in its destruction of Afghanistan are a testament to this.

new fundamentalism of a US led globalization where the United States regards itself as bringing the gospel of the free market and democracy to the infidels outside the West. It is those very infidels that are in the best place to witness this hypocrisy as they watch their markets shredded by IMF and US economic policies while their democracies are subverted by US support for totalitarian regimes. It is estimated that over a billion people are undernourished and seven million children die each year as a result of the debt owed by third world countries to the West (Ali, 2002). It takes a very solid fundamentalism to allow so much suffering in the service of a market that will never be free and a system that will never be democratic. With the weak moral order of the Cold War gone, an infinitely more chilling one has replaced it (Juergensmeyer, 2000), one that appears to provide only political uncertainty, a vapid, Americanized consumerism, militarism and economic devastation to most of the world.

If those concerned with protecting evolution and science from the dangers of dogma and religious irrationality were really serious, they would look to its contemporary causes rather than create some sort of mythic, timeless fundamentalism that has always sought to oppose science and the modern world. If there is an attack on the legitimating institutions of the West, which science has long been, the reasons might quite different than science and the media project. The elitism and arrogance of science, like the elitism and arrogance of US global policy is increasingly coming under fire, recognized as the self-serving, myopic dogma it has long been. Like the US without the pretence of a transcendental democratic ideal, US science as well as US public education without its own transcendental fictions must take a new look at itself, recognizing what many other have come to see. The postmodern "democratization" of science is, perhaps, a temporary deferment of an honest look at science like US "democratic" multiculturalism is for US education and democracy. But like the other great rationalizing institutions of the American liberal-democratic system-civil law, consumer culture, prison, medicine, media, family-each in their own way promising us democracy but delivering only an elite-dominated economic liberalism, science is losing ground. Perhaps in its stead one will find a new source of knowledge production that is truly anti-dogmatic, democratic, historical and intellectual, less obsessed with controlling nature to meet human ends and perhaps even willing to reopen the question of the spiritual and of the ineffable-all this located in a newly reorganized life-long public educational system that regards the creation of a critical citizenry as a primary and most magnificent goal.

Conclusion: A New School-Science

This dissertation has sought to trace some of the history of the ideational and material structures which underlie US society. As I hoped to have demonstrated, many of these structures seek to mediate liberalism and democracy, usually at the expense of the latter. The more difficult it was to "protect" democracy from the poor, workers, immigrants, and minorities, the more sophisticated and interrelated these structures became and the harder they would work to rationalize and legitimate the inequities of US society. Science and education are two such structures. Over the past two centuries, nature study became Big Science, a corporatized, anti-democratic, elitist source for producing legitimate knowledge and wealth in the form of technology, while education became schooling, a mechanized, factory-like site for reproducing the social relations which already exist in contemporary America. As these structures came together, instrumental science and schooling, they formed a science education that mostly borrowed the worst from both--a pedagogy of facts as distinct from dead processes which teach children to follow instructions properly and prepare them to become uncritical consumers of scientific knowledge and technology. All the while, instrumental science acts as if its truly skeptical and anti-dogmatic, schooling acts as if it seeks to provide a well-rounded, critical education and science education perpetuates these myths. As I have also identified, there are alternatives, some which already exist and some which we can only begin to imagine. In this conclusion, I want to draw out just what those alternatives might look like. I want to use a new vision of science education to begin to lay out a plan for transforming science education, education and eventually science.

If contemporary science education serves to legitimate and rationalize the American liberal-democratic system, disallowing a substantive critique, how can one develop an alternative that is more critical of these foundations? Now that I have satisfied the question of why schools teach science in the first place, perhaps a new vision of science can offer a new logic for justifying science in schools? To begin with, it might make sense to divorce science-in-schools from science itself. This seems like an odd proposition. Over the past century, educators have argued the school-science should look more like real science and I am suggesting precisely the opposite. Let's backtrack a bit. In my view, the sign of a good education involves the capacity for independent and creative thought, especially thought that is directed at the conditions of one's life and the conditions of the lives of those around you. This kind of education can offer individuals the opportunity to think through options in life, and hopefully, widen their scope of choices. Most importantly, they might recognize when those choices are limited by social, economic and/or political institutions and work to change them. One needs various "tools" to do this-the ability to read, write, speak, acquire and utilize information, understand one's cultural heritage/history as well as the history of others, and so on. Other more "pragmatic" educations can follow from this, but they are a response to a thoughtful reflection on one's life and living conditions. This inspires the "pragmatic" rather than the other way around. Teaching the "basics" comes after the development of a perspective rather than before. Much of this is said far more eloquently by others and I don't want to tread old ground, but my point is only that science education should and can fit into this kind of educational paradigm.

The Enlightenment vision of science-skeptical, anti-dogmatic, ethical, even theoretical and historical--though it never really existed except in a few rare moments--is still an ideal worth striving for. Naturally, Enlightenment science needs some qualifiers. Its historical insensitivity to issues of race, gender, class, nation and sexuality are not ones which need to be repeated. As I indicated, there were moments in Enlightenment science when the value-laden nature of knowledge was understood. And when it was ignored, it was a radical move for that time, but no longer. Our science needs to move away from objectivity or "the view from nowhere" and admit that knowledge is grounded in a perspective, a fact which limits the transcendent claims science can make (Haraway, 1991). Although real science in the twenty-first century looks nothing like this, perhaps school science can? Perhaps the revival of Enlightenment ideals comes not through the transformation of the institutions of science which are so thoroughly wedded to the contemporary order that it is difficult to know where to begin to change them, but in schools, in curricula that adopt a "scientific" attitude, even if this attitude looks very little like the one adopted by science itself. This is what I mean by divorcing school science from real science, it is from school science, I suggest, that a more critical vision of science can be articulated. One of the differences between real and school science is that, presumably, everybody does the latter. It is democratic in a way that institutionalized science is not. What if we gave children the skills they needed to do "critical science?" What if we sent them out into the world with the idea that they, like everyone else, could "do" science all the time? What if we told them that what they did was the "real" science and what is done by the State, universities, corporations, and others is a debased version of the real thing?

In certain respects, these ideas hark back to the distinction between the two versions of science I identified previously-a technocratic vision and nature study. Clearly, the former is dominant, though it uses the rhetoric of the latter, that it has unfettered access to nature, when it needs to legitimate its work. But what about a science of "nature" study that did not seek timeless truths, but understood that it looked at the world from a perspective? This version of science could recognize that its work also involves an interrogation of those observations and perspectives through the lens of theory, social criticism and history. Students are now taught that the technocratic vision of science, the science that is ceaselessly inventing things, making our lives easier or more difficult depending on one's perspective, is science. But, this is far from the skeptical vision of science put forth in the eighteenth century. I would argue that a variant of the latter version is the "scientific" one and the other is "technique," valuable, but not science as I wish to define it (Ellul, 1964). Some might object to this sort of distinction as, in reality, modern science is both, but perhaps distinguishing between the two can assist us in creating a science to be taught in schools which teaches students to think in ways that can really make a difference in their lives? Perhaps it can offer students a means to appreciate the natural and social worlds in terms that they themselves create?

The idea that students actually create this knowledge is key. Another distinction worth making is between a Kantian science and a Goethe-ian science. The former, which is dominant, seeks to abstract the tools of research from the personality that does the research. It is a science of method. The latter is precisely the opposite. It is the work of genius. Not "genius" in the terms of the "intelligence" or IQ paradigm as we have come to understand it in the United States, as a sorting mechanism, but genius in the sense that recognizes how an individual's uniqueness always infuses the knowledge they produce. Against the Kantian science paradigm, knowledge is highly personalized.

Since the early forms of science education in the United States, there has been the assumption that its job is to sell or support US science. Science education has become a tool for scientific evangelicalism. Instead, I would suggest that school-science position itself in tension to science-as-practiced. This means that good school science does not try to mimic scientific research, as say in the case of the Westinghouse and other science scholarships, but good school science studies science itself or aspects of the world that science ignores. School science can ground an entire curriculum that is less interested in "socializing" children to the world as is, than helping empower children by allowing them to develop their own perspective on the world, a perspective that can and should be critical of some aspects of that world. This kind of science education leads easily into a broader conception of education. It is vital to protect the diversity of perspectives, even if one doesn't always agree with them. Such is the nature of democracy. Too many institutions in the United States are designed to communicate to those that live in its spaces that we live in the best possible of societies, to reproduce variants of American exceptionalism. Educational institutions should be organized to do precisely the opposite, to point out the failings of our society, and a critical school-science program can do just that.

This new curriculum would not require the division between facts and process that has obsessed science educators for the past century. In order to understand what one or others see in the world-these would be "facts"-one needs to interpret those observations in the light of theory and history-this is a process. Memorizing facts for their own sake is useless and doing process for its own sake-as is now the case with much school science-is just as pointless. The kinds of lessons in many of the standards documents are too often these kinds of empty processes that are dictated by science-as-practice in the sense that real science determines the object to be studied, all legitimated through "research" or what I have termed the scientifization of education. As every good educator knows, and Dewey was at pains to point out, education is not simply a "science," it is an art. Perhaps the same is true of science.

This explains why students spend so much time doing busy-work. In elite schools, the students do "real" research which looks more like what scientists actually do, but again this is not a vision of school science I would support unless the goal is simply to produce a cadre of graduates ready to circulate in the highest corridors of power in American life. Instead, objects to be studied should be determined by the needs of the students, schools and communities. The asthma-study I discussed in a previous chapter is a better example of this. One can find many other instances of such kinds of lessons in US public schools created by innovative teachers or school leaders, but they tend to remain the exception rather than the rule and are often hampered by their relation to what they conceive to be real science. I want to stress that I am not saying that schools should not teach some of the traditional subjects of school-science-knowing the way some science describes the workings of the body is quite useful-but even here much of the "facts" are still in dispute, as I suggested with the case of the discourse of gene action. I would go as far as to suggest that not all school science need be explicitly critical. Categorizing plants, for instance, can help to develop a language for appreciating the natural world, a value I certainly would support. But even the categorization of plants has a rich history grounded in debate.

This leads to another key idea. If school science is to be a real illustration of the capacity of the United States to democratize knowledge, then what school science studies should be decided in more democratic ways and not by scientists or educational experts. This creates a host of complications. This might mean that creationism, for instance, returns to the classroom. However, I would argue, this is not necessarily a problem in a critical science classroom. If the attitude encouraged in these classes is truly one of anti-dogmatism and skepticism then both creationism and evolution can be treated from similar perspectives. Students can examine the "facts" for both, but also look at the long history of both perspectives which complicates the idea that they are simply theories to explain the origins of life and even that they are truly distinct paradigms. Creationism can be taken to task for its dogmatic reliance on the bible and evolutionary theories can be similarly taken to task for their dogmatic selectionist and gradualist bias. Other creationisms which are more flexible on the question of biblical inerrancy can be introduced as well as evolutionary perspectives that challenge Darwinism.

In other words, while school science has traditionally tried to simply scientific debates and problems, when it does teach the topics of "traditional" science, it should do just the opposite. Such lessons can help demonstrate to students that at bottom, as is the case with all science, these "theories" represent ethical perspectives about the world. From this reality choices about facts need be made. When done well, evolutionary debates can provide an exciting illustration of a critical science. The same is the case with other topics of contest including genetics, the ineffable/God, technology, cognition/mind, and ecology. The most interesting science is the science that is not completely resolved, or as Bruno Latour would put it, "black boxed," for it is in these cases that the theoretical, historical and ethical can be made most explicit.

As I hope to have explained, science education need not be a tool for Big Science nor a tool for schooling. It need not be a tool to legitimate or rationalize the world as is. It can be a model for an alternate conception of education, one that sits in tension with the world rather than easily integrates into it. Just as Big Science recognizes that schools are one of the last opportunities to teach the kinds of values that it wants to instill in people-passivity, consumption, dogmatism-I hope the rest of us can recognize that schools are the last opportunity to teach the opposite lessons. Many people don't seem to want schools to be an antagonist of society in this way. John Taylor Gatto's, a former New York State Teacher of the Years, wonderful *Dumbing Us Down: The Hidden Curriculum of Compulsory Schooling* (1992) has much to say about the "real" lessons of school-emotional and intellectual dependency, indifference, confusion and surveillance. US schools are generally not spaces where people develop into independent, creative thinkers. At best, they produce graduates with the skills to get jobs. This says much about the shallow conception of education many in the United States now support.

US society has never been all that good at tolerating much skepticism, critique or dissent, and that is still the case. And yet, it has always found better ways of dealing with dissenting ideas than the Europeans who seem to turn to authoritarianism every now and again. If US society is based on the kinds of mythic rationalizations and dogmatic legitimations I have suggested, then the importance of science education, schooling and instrumental science follows quite coherently. However, if my argument about globalization's tendency to dismantle the rationalizing and legitimating institutions of the West (with the exception of capital accumulation) is correct, then school curricula are in the process of dramatic change anyway. A critical curriculum might suddenly become attractive to a lot more people when faced with a choice between it and the McCurriculums that I expect will rise in their stead.

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