

The Promissory Future(s) of Education: Rethinking scientific literacy in the era of biocapitalism

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Abstract

*This article investigates the biopolitical dimensions that have grown out of the union between biocapitalism and current science education reform in the US. Drawing on science and technology study theorists, I utilize the analytics of promissory valuation and salvational discourses to understand how scientific literacy in the neo-Sputnik era has deeply involved educational life in biocapitalist circuits of exchange and production. I lay out this emerging terrain of 'futurity' through a biopolitical analysis of the National Academies highly influential policy recommendation on science education, *Rising Above the Gathering Storm* as well as the Association of American Universities' National Defense Education and Innovation Initiative. Here it is argued that the educational subject usually seen as a site of human capital investment can better be understood as a 'biovalue' in at least two senses: the educational subject's body as a site of investment and as an extractable source of value directly related to the larger globally competitive regime of the rapidly growing bioeconomy. I conclude my analysis of the vital politics at play in the biocapitalist articulation of science education with an alternative model of scientific literacy that is based in what I call biodemocratic practices. I explore such a rereading of scientific literacy through the example of the *GrowHaus*—a sustainable urban farm situated in a marginalized community in a major US city. The *GrowHaus* offers a model of scientific literacy that rejects extractive ethics associated with biocapitalist production and instead promotes a sustainable and socially just practice of science.*

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The future man, whom the scientists tell us they will produce in no more than a hundred years, seems to be possessed by a rebellion against human existence as it has been given, a free gift from nowhere (secularly speaking), which he wishes to exchange, as it were, for something he made himself. There is no reason to doubt our abilities to accomplish such an exchange, just as there is no reason to doubt our present ability to destroy all organic life on earth.

Hannah Arendt, *The Human Condition* (Arendt, 1958, p. 3)

Introduction: Educational Life and Biocapital

In recent efforts to bridge the literatures of biopolitics and educational theory an important dimension has emerged. On the one hand, drawing on the work of Italian political theorist Giorgio Agamben, a productive space has been opened up in which to think about the educational subject within an increasingly regulated complex of surveillance, measurement, and sorting technologies associated with zero tolerance practices in schools (Lewis, 2006).¹ Here Tyson Lewis suggests that schools in the US can be viewed more akin to what Agamben calls the camp, where the bodies of students are treated as non-vital, biological material subjected to forms of sovereign power that normalizes the exclusion of educational life from democratic life. On the other hand, utilizing Foucault's theory of biopower and human capital, the educational subject has also been theorized as a self-investing, entrepreneurial individual shaped through a variety of governmental regimes that promote a neoliberal ethic of self care (Peters, 2001, 2005; Simons, 2006; Peters & Besley, 2007). This line of analysis points out that student subjectivities formed within matrices of neoliberal governmentality have fallen under a 'regime of economic terror and learning as investment' through a variety of market-based interventions (Simons, 2006).

In these biopolitical articulations within educational theory an important point of convergence appears: a zone where educational life is understood as a strategic site of intervention that can be managed and controlled through forms of biopower. While these authors have pointed to important biopolitical aspects of current educational practice and governance, this essay investigates perhaps the most potent regime of educational biopower operating today. Resting at the intersection of 'biocapitalism' and the neo-Sputnik science education reform movement in the US is a deeply troubling biopolitical project. Emerging from the promissory landscape of biocapitalist forms of education is an educational subject that is being shaped through a developmental model that involves life in circuits of exchange and valuation in disturbingly novel ways. It is this feature of biopolitical production, its ethical model that can best be described through its extractive relationship to forms of life, which is the subject of inquiry in this essay. Reading science education in the age of biocapitalism through a biopolitical lens, I contend, reveals a co-productive project that at once creates subjects who embody an extractive ethic and whose body is also the target of extractive forms of biopower.

As a concept developed within the fields of anthropology of science and science and technology studies, biocapitalism has been theorized as a (re)productive model that arose from the complex set of relations existing between technoscientific research and neoliberal practices of economic development.² One of the defining features of biocapitalism is a 'mode of generating biocapital [that] is driven by a form of extraction that involves isolating and mobilizing the primary reproductive agency of specific body parts, particularly cells, in a manner not dissimilar to that by which, as Marx described it, soil plays the "principle" role in agriculture' (Franklin & Lock, 2003, p. 8). In this essay I draw upon such an understanding of biocapitalism that focuses on how forms of life (genes, cells, reproductive organs, chemical compounds of plants, or educational life) have become the target of a powerful productive regime.

The argument I make in this essay is that in order to obtain a deeper understanding of the biopolitical terrain of high-stakes schooling (where science education is situated prominently) it is necessary to investigate how biocapitalism and the set of extractive practices it is built upon as a model of development interface with the project to adjust the future to a past where ‘the American Century and the Human Capital Century occurred together’ and ‘follow[ed] directly from the relationships among growth, technology, and education’ (Goldin & Katz, 2008, p. 2). The connection between human capital and biocapitalism is particularly important to map since the human capital understanding of education is foundational to the science education reform movement that is oriented toward a co-productive relationship between scientific literacy and biocapitalist economic imperatives. The concept of scientific literacy as it is operationalized in the current neo-Sputnik movement, in other words, cannot be understood outside the emergent regime of biocapitalism and the forms of subjectivities needed for its promissory futures to be realized.

The concept of scientific literacy is certainly not a monolithic one. In this essay I focus on the dominant notion of scientific literacy as it is being constructed through the current science education movement, which I argue embodies a biocapitalist ethic. Perhaps the best work being done on more democratic versions of scientific literacy in the field of education is Wolf-Michael Roth and Angela Calabrese Barton (2004). As opposed to top-down models of science education that impute a traditional form of literacy focused on learning the inquiry process of science and its methods, Roth and Barton ground the development of scientific literacy within participatory contexts that favor a notion of literacy that deals with problems affecting communities directly, such as water pollution, soil contamination, or access to healthy food. Derek Hodson and Nancy Brickhouse’s work in science education also strongly forefronts democratic configurations of scientific literacy that challenge racist and sexist values embedded in traditional science education curricula (Hodson, 2003; Stanley & Brickhouse, 2001; Brickhouse & Kittleson, 2006). While the articulation of scientific literacy in the work of these theorists and educators are productive and much needed, none deal with the biopolitical dimensions of scientific literacy as I address them here.

In laying out my analysis I begin by briefly identifying some of the central characteristics of biocapitalism that science and technology studies theorists (STS) have developed in their work. Specifically, I draw upon the interrelated analytics of promissory investment and national salvation for constructing my biopolitical critique of the science education movement in the US. I choose these categories because they have become a decisive force in shaping the science education reform movement in the US and in turn what the concept of scientific literacy will mean now and in the future. Next, I turn to the clearest example of science education policy that reflects the expanding influence of biocapitalism on the pragmatic development of scientific literacy. The National Academies’ *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (National Academies, 2007; RAGS hereafter) is the latest iteration of a neo-Sputnik fervor that is placing intense pressure on educational institutions to develop subjects who are capable of competing in a high stakes global economy and participating in a nationalistic project for reasserting US economic hegemony—especially in the areas of biotechnological and biomedical research and development. As

framed in RAGS, the future security and economic health of the US hinges on the prospect of increasing the supply of human capital attuned to the types of labor *and* life that the biocapitalist mode of production requires.³ What is at stake in the science education reform movement, and one important area I explore below, is how the very security of the US as a global economic superpower, particularly in the area of biotechnological innovation, is a foundational concern driving biocapitalist production. As such, RAGS, and the science education movement in general currently building inertia in the US must be read within the larger bioeconomic terrain in which many of the most powerful industries and governments in the world have hedged their future.

Yet a large part of understanding the connection between the neo-Sputnik fervor of RAGS and biocapitalism is seeing how human capital theories of education are utilized for articulating the pedagogical goals of educational reform today. The human capital model of education, in other words, is pivotal to the success and advancement of biocapitalism and, as such, unpacking the relationship between the two sheds new light on how both are rapidly evolving through a seemingly insatiable desire for subjects highly invested in the skill sets amenable to technoscientific research and development. Clarifying this connection is also important since the notion of an educational subject as a self-investing, entrepreneurial individual enjoys almost unquestioned popular and governmental support. From its early origin in the work of Chicago School economists Jacob Mincer (1974) and Gary Becker (1993), to *New York Times* editorialist and author Thomas Friedman, to the Obama administration's Department of Education, human capital still remains one of the most influential theories shaping both the individuals' and the publics' understanding of the purpose of education in society today.⁴

In the final section I begin to sketch an alternative biopolitical model of science literacy that operates from a different 'politics of vitality' from the one produced through the human capital model of education prevalent in the biocapitalist era. In developing a provisional framework for an alternative scientific literacy, I turn to the example of the GrowHaus urban farm project. Situated in an under-served and marginalized Denver neighborhood, the GrowHaus represents a political space in which to rethink how the human capital model of education can be reconfigured into a pedagogical device for creating a vital politics that does not operate with an extractive ethic. In other words, I propose that we approach the human capital model in an experimental manner as a way to think through potential alternative biopolitical variations of education that are not tied to an extractive ethic of life but instead one that promotes a healthier and more sustainable form of 'biocitizenship'. More precisely, in turning to Michael Hardt and Antonio Negri's concept of immaterial labor as a bridge, I want to look at how the ethic of self-investment underlying human capital models that relies on a mastery of immaterial labor can be transformed within learning environments such as the GrowHaus to reverse the power relations currently shaping understandings of life in educational contexts. Such alternative practices of educational investment can be seen as substituting a different 'biovalue' into the 'ability machine' that the educational subject has become in the contemporary moment. Such a reorientation of human capital points to the development of an ethic of biological and ecological health as an alternative model of biocitizenship that can replace the promissory and salvatory model utilized in biocapitalist models of education. Ultimately, what I argue is needed today is an alternative

model of biopolitical production of education that is built upon a reconfigured concept of scientific literacy that rejects biocapitalist forms of life and the vital politics it produces, something better attuned to what I term the biodemocratic.

Before I discuss what an alternative biopolitical construction of scientific literacy might look like in educational and social settings, some of the distinguishing features of biocapitalism need to be outlined. Specifically, the promissory value framework and salvatory ideology embodied in the spirit of biocapitalist development, as they are integral to the larger analysis being developed here. These prominent features of biocapitalism are important to understand because, as pointed out in the second section, they have been absorbed into the science education reform movement and the concept of scientific literacy it articulates.

Biocapitalism and the Rise of Promissory Pedagogy

One of the principle dynamics energizing the regime of biocapitalism is its propensity to surmount limits to growth in both cultural and natural domains. Yet unlike Marx and Engel's industrial capitalism, it is not so much new lands, materials, and labor in the traditional sense that biocapitalist actors are targeting as extractive fields; rather it is 'life itself'.⁵ Perhaps the best venue in which to view the circuits of biocapitalism and where STS theorists have focused much of their attention, is on the biomedical, biotechnological, and pharmaceutical industries. One of the fundamental goals of biocapitalism can be detected in how 'bioeconomic circuits of exchange have as their organizing principle the capturing of the latent value in biological processes, a value that is simultaneously that of human health and that of economic growth' (Rose, 2007, pp. 32–33). Here Nikolas Rose hits on one of the most salient qualities of biocapitalism: its capacity to commodify and make exchangeable vitality in a variety of forms. For example, plant seeds, DNA material, human organs and tissue, information systems integral to processing and reading genetic code, as well as human test subject data are all exchange values within the growing bioeconomy that has arisen in earnest in the past 20 years or so. In making a connection between the biocapitalist propensity to extract latent value from life to the science education reform movement, however, it is necessary to first look briefly at how neoliberalism helped fuse together the enterprise of science with unbridled economic growth, a union that sits at the center of biocapitalist development.

At the most superficial level, biocapitalism has evolved out of neoliberal economic restructuring that began in the late 1970s in the UK and US and is generally associated with the removal of restrictive barriers to markets and labor through governmental, military, and corporate intervention. Thus, the privatization of public infrastructure (schools, water, roads, forests), the individuation of risks (health care, natural disaster responses, waste management, admission and access to higher education, etc.), and the strategic use of military and corporate forces in responding to social and economic crises are all signature qualities of neoliberal governmentality (Harvey, 2005; Klein, 2007; Foucault, 1978, 2008).⁶ Most relevant to this analysis, however, is the elimination of proprietary boundaries in key knowledge producing sites such as the university that became legally sanctioned through the passing of the landmark Bayh-Dole Act of 1980. In effect, the Bayh-Dole act legalized the partnering of publically funded academic

research sites with corporate and governmental entities which, in turn, opened up new profitable places of production (and investment) in areas such as biomedicine, biotechnology, and biopharmaceutical while completely erasing the line between public/private sites of knowledge production (Haraway, 1997, 2007; Kleinman & Vallas, 2001; Rajan, 2006; Cooper, 2008).⁷

The coupling of academic science departments with the biotechnological and biomedical industries has helped push the neoliberal model of growth into entirely novel regions. Never before in the history of human civilization has an economic system tied so closely the fragile processes of life to a model of development. Vandana Shiva's work on biopiracy, in particular, has been invaluable in mapping out the neocolonial phase of exploitation and proprietary ownership that has arisen with the institutionalization of transnational trade agreements such as the 1993 Trade Related Aspect of Intellectual Property Rights (TRIPS) (Shiva, 1997, 2005). Other governmental/corporate bio-prospecting entities like the International Cooperative Biodiversity Groups (ICBG) have also blurred the line between free market ideology and academic research in troubling ways as it has been instrumental in 'forge[ing] an initiative that would link drug discovery to sustainable development precisely through benefit sharing contracts' that privilege corporations such as Merck and Wyeth-Ayerst while stripping local communities of their ecological and cultural biodiversity (Hayden, 2003, p. 66).

The genealogical feature of biocapitalism most important to the present analysis is how the neoliberal revolution encoded within the sociology of science (thus reshaping what is needed from the educational system) an insatiable drive to overcome both institutional *and* biological limits to growth. As a consequence, one of the most important effects of the biotech revolution that followed the merging of private and public research was an opening up of 'a whole series of legislative and regulatory measures designed to relocate economic production at the genetic, microbial, and cellular level, so that life becomes, literally, annexed within capitalist processes of accumulation' (Cooper, 2008, p. 19). Indeed, one of the most far-reaching effects of the neoliberal project was its driving of economic development in areas of technoscientific research that made it possible to transform biological life into a zone of economic territorialization and commodification. It is this co-constructive relationship between neoliberalism as a developmental strategy and the life sciences that underpins biocapitalism and also contributes to the formation of one of its most pervasive characteristics: its promissory value framework.

In his theoretical mapping of sites of biocapitalist production, Kaushik Rajan clearly depicts how promissory value permeates private and governmental entities that largely hedge their future on not yet existing goods. In particular, his analysis of biotech start-up labs and the individuals who are involved in their operation and success accentuates how promissory valuation is a key constituent of biocapitalist production. One of the underlying themes Rajan points to in biotech productive contexts is an ethic that heavily rests on:

... forms of valuation having not to do with the tangible material indicators of successful productivity, but with intangible abstractions, such as the felt possibility of *future* productivity or profit. Vision, hype, and promise ... are

fundamental drivers of this kind of valuation and are central animating factors in drug development, whether it involves the valuations of start-ups by private investors such as venture capitalists, or the valuation of public companies on the stock markets of Wall Street. (Rajan, 2006, p. 18)

Rajan's point here is that biotech companies, as paradigmatic biocapitalist actors, operate in a speculative environment that drives growth based on a particular vision of investment oriented toward future promises of productive potential instead of ones based on existing or real value. It is this focus on imaginary productive potential built into the biocapitalist notion of progress that I want to draw out in order to better understand the construction of scientific literacy in the contemporary moment.

As indicated above, the promissory ethic embodied in biocapitalist sites of production such as genomic research labs is one made possible through the dynamic relationship established between technoscientific research and biotech industry. As such 'the grammar of biocapital is a consequence of the type of capitalism that it is. As a type of high-tech capitalism, biocapital is, certainly in the U.S. context, often *speculative*, a reflection of commercial capitalism almost to the exclusion of commodity capitalism' (Rajan, 2006, p. 111). Echoing Rajan's insights on the promissory valuation at work in biocapitalist circuits of production, Cori Hayden makes a parallel point in her research on pharmaceutical bioprospecting in Mexico. Embedded in the extractive relationship established between indigenous communities, a US and Mexican University, and a giant pharmaceutical company sanctioned by international governing boards of trade is a type of exchange that is infused with what Hayden identifies as an ideology of 'futuricity'. As Hayden points out 'in the UNAM-Arizona agreement, as with countless prospecting projects, "the product" has not (yet) materialized: it is a promise that may remain just that' (Hayden, 2003, p. 74).

It is this speculative ethos driving some of the most powerful areas of the economy that will be important to keep in mind when I examine aspects of science education reform in the neo-Sputnik era below. As I argue, much in the same way that investment into imaginary drugs fuel biocapitalist development, a similar promissory framework is present in the construction of educational subjectivities in the biocapitalist era. Thus one of the most important attributes of the promissory value framework of biocapitalist production informing this investigation is its ability to make valuable something that has not yet come into being. As a result gene therapy drugs, the chemical compounds of plants, and educational subjects, at one level, are all treated as potential exchange values that have been conflated within the imaginary productive zone of the promissory horizon created in biocapitalist society. Yet investing in such a potential future is also driven by a strong faith in the ability of biocapitalist progress to place nations into positions of global power. Part of the biocapitalist vision of the future, in other words, also has a lot to do with market and governmental dominance in a highly competitive global economy.

The second feature of biocapitalism being articulated in environments such as the start-up lab that is related to the formation of current science education policy reform is the 'risk management' discourse of national salvation. That is, as Rajan's analysis of genomic research laboratories reveals, biocapital firms that function with a currency of promissory goods tend also to retain a pseudo-religious ideology that links success in

technoscientific research to that of the salvation of the nation. It is at this intersection between technoscientific research and national security rendered in the high stakes biocapitalist context that an important political dimension of science opens up that usually remains obscure. Namely, how ‘the promises of biocapital are undergirded by salvatory and nationalist discourses’ which have ‘salvatory stories ... embedded in the ethos of specific corporate cultures, and in the cultures of biotechnology and development industries writ large’ (Rajan, 2006, p. 35). Here it is clear that one of the latent yet constituting features of biocapitalism is the unwavering faith put into its productive framework that brings with it a very potent nationalist discourse linked to notions of security, territorial hegemony, and citizenship. This risk management aspect of biocapitalism plays a significant role in the construction of scientific literacy as it is articulated in the security-oriented science education movement of the neo-Sputnik era.

The compression of scientific progress into national security strategies that has taken place in the biocapitalist production paradigm has an important effect on the formation of subjectivities in sites of scientific practice (and by extension science education settings) and is worth considering more closely. An instructive place to look for understanding how such a transfer between national security and technoscientific R&D occurs is biocapitalist sites of production such as the biomedical research lab. The genomic lab is an important model for understanding the salvatory trope of biocapitalism because it represents a zone of subjectivity production that the science education reform movement is seeking to replicate. High-pressure biotech labs, in other words, reflect ‘the co-constitution of highly individualized stories of personal motivation, calling, and human interest with the structural messianism inherent in the market, science or nation’ which has the effect of making the act of ‘saving lives meld into saving a company’s corporate interests or, in the case of India, making a “Third World” country a “Global Player” ’ (Rajan, 2006, p. 198).

What Rajan’s study of both US and Indian biotech actors uncovers is the emergence of a powerful discourse and practice he calls the ‘born again ethic’ of biocapitalism. Thus, in the case of human genome research, a sort of new logic of capital has developed that has a powerful effect on the production of subjectivities according to Rajan—a logic that is infused with an unflinching belief in the biosciences and their ability to discover the next ripe market to be exploited for profit and glory of nation. Yet this salvatory ethic also points to a neo-Weberian melding of religious and capitalist values that is also shaping notions of citizenship through the belief system of neoliberal free market ideology and American exceptionalism. Here citizenship has more to do with saving one’s country through scientific and technological superiority than it does with traditional civic values such as rootedness in community, rational communication and debate between diverse members of society, or the cultivation of these general civic virtues through a system of public education. What emerges from Rajan’s analysis of the biocapitalist productive framework, therefore, is a model of citizenship that is tied to an idea of nation that mirrors the enterprise of high stakes technoscientific research that takes place in some of the most economically volatile environments in society.

The salvatory character of biocapitalism has also been a large part of Rose’s work on charting the rise of the bioeconomy as a dominant sector of investment for

governments around the globe. For example, Rose notes that ‘in 2003 the U.K. House of Commons Trade and Industry Committee Report on Biotechnology identified biotechnology, especially biomedical biotechnology, as a key economic driver and estimated that, in 2002, the U.K. biotechnology industry had a market capitalization of £6.3 billion, accounting for 42 percent of the total market capitalization of European biotechnology’ (Rose, 2007, p. 35). The UK is not alone, however, as Rose also points out that countries such as China, India, and South Korea share this salvatory vision in the emergent bioeconomy. For Rose then ‘political investment to support the development of the biotechnology sector in each country and region was driven, at least in part, by fears of the consequences of losing out in this intense international competition’ (Rose, 2007, p. 36). Given the amount of faith governments and nations have put into the bioeconomy as the most important economic sector, it is not surprising that a corollary notion of citizenship has also arisen in such a salvatory context. Here success in the labs and markets of the bioeconomy is directly related to the supply stream of highly technoscientifically literate subjects that a country can produce. In such a model civic duty is largely measured by one’s ability to help their country compete in ‘an intense international competition’ rather than a democratic political life.

Here we have reached a key point where educational need and biocapitalism intersect. Coupled to the promissory and salvatory ethos of biocapitalism, as I argue below, is the need for educational subjectivities that retain the proper types of investment most useful to the productive framework of biocapitalism. Scientific literacy, and in particular how it is being defined in our neo-Sputnik moment, is the most important mechanism to view for understanding how the regime of biocapitalism is reshaping education into its own image. Yet key to making sense of how scientific literacy is at the center of such a project is seeing how the theory of human capital underlying science education reform instills the promissory and salvatory ethic as a primary mode of conduct for the educational subject. The relationship developing at the nexus of education and biocapital is one where the future-oriented individual who is perpetually investing in his or her life to increase levels of human capital and participate in a ‘race to the top’ mirrors the ethic of the biocapital actors of the lab.

Vitality and Human Capital Education

Human capital education, when viewed alongside the promissory value framework of biocapitalism, a project clearly geared toward producing a particular type of educational vitality, becomes apparent. The principal problem I want to investigate in this section is how scientific literacy has become the key mechanism for shaping educational life in a way that is congruent with the biocapitalist imperatives of promissory valuation and salvatory discourses. This question is a crucial one as scientific literacy is now more than ever geared toward fulfilling the needs of a rapidly evolving bioeconomy. Not surprisingly, the project for defining scientific literacy is being led by some of the most powerful industries in the US and across the globe. The pharmaceutical, biomedical, and biotechnological industries, three of the most prominent sectors of the global economy, have become primary drivers for determining the direction and social future of the US economy. As such, they also have a steep demand for particular kinds of educational

labor and skill-sets that is reflected in the recent increase of governmental spending patterns over the past decade. For example, US pharmaceutical research and biotechnological companies, despite a historic economic downturn, have invested a record \$65.2 billion into new R&D in 2008 alone (PhRMA, 2010). On top of such massive spending, the Obama administration and the US congress have also allocated \$10 billion for scientific research that is tied to The American Recovery and Reinvestment Act. The US government in addition also indicated that three percent of the annual GDP will go directly into bolstering efforts to increase scientific and technological research in the US, STEM (Science, Technology, Engineering, Math) education being one of the most important loci of this legislation (American Recovery and Reinvestment Act, 2009).

The need for educational lives attuned to the skills, knowledge, and modes of analyses that are built into the knowledge hungry bioeconomy places the struggle to define scientific literacy at the heart of economic recovery. As such, both sides of the political spectrum in the US are pushing for a notion of scientific literacy that can feed directly into the demands created by biocapitalism and the promissory value model it adheres to. What needs to be recognized in this effort is how the desire to manage student populations in a manner that produces individuals who are appropriate for the techno-scientific workplace is also part of a larger venture model of investing associated with biocapitalism: increasing investment in STEM education has a high potential to yield dividends in the form of potential knowledge workers. Software developers, data interpreters, biochemical, biophysical, and genetic researchers are the desired labor base of biocapitalist society and schools, as it turns out, have been targeted as one of the most important promissory production sites.

In this sense, scientific literacy within the biocapitalist context can perhaps best be understood as a strategy focused on the production of educational subjects who retain a particular type of 'biovalue' that shares in the promissory ethos of the bioeconomy (Rose, 2007).⁸ By interpreting educational subjects as forms of biovalue, scientific literacy can more accurately be recast as a technique for managing and regulating educational life as a field of extractable value. One of the most successful ways scientific literacy attempts to achieve its extractive goals is by drawing upon and reconfiguring the human capital ethic which already serves as the basis to the current science education reform movement. By setting scientific literacy within the biocapitalist framework, the organizing field of biopower that normalizes the process of capturing latent value from educational populations becomes apparent. It is on this axis where human capital as a theory and practice of education should be reread as an integral part of the larger goal of science education reform aimed at cultivating forms of life suitable for biocapitalist modes of production. Science education, as conceived within the milieu of biocapitalism, in other words, is a space analogous to one that 'can be known and theorized, that can become the field or target of programs that seek to evaluate and increase the power of nations or corporations by acting within and upon that economy. And the bioeconomy has indeed emerged as a governable, and governed, space' (Rose, 2007, p. 33). What I am suggesting requires further examination is how the theory of human capital operating within the science education reform movement participates in a project that has as an aim increasing the biovalue of educational life. One of the best places to view such an extractive logic at work is in the National Academies' legislative recommendation RAGS.

Not unlike the tone of fear that fuelled educational reform during the cold war Sputnik era, RAGS has unmistakably placed science and math education within the matrix of national security and economic salvation with a renewed intensity. Building off the Hart-Rudman Commission's flurry of homeland security measures, RAGS embodies the view that 'the inadequacies of our system of research and education pose a greater threat to US national security over the next quarter century than any potential conventional war that we might imagine' (RAGS, p. 25). Remarking on the seriousness of the threat that a declining science and technology research sector represents to the US, former president George W. Bush has also warned that 'science and technology have never been more essential to the defense of the nation and the health of our economy' (RAGS, p. 25). An obvious question that surfaces in the face of such catastrophic rhetoric, which is not limited to the neoconservative perspective, is what rationale lies behind such a line of thought? One place to look for an answer to this question is one of the most influential arguments made in constructing the theoretical point of view of RAGS that explicitly ties salvatory narratives and national security concerns to science and math education reform. Here Thomas Friedman's 'quiet crisis' thesis which hinges on the human capital theory of education is highly influential to the theoretical foundation of RAGS and thus is worth briefly examining.⁹

Friedman's concept of a quiet crisis is generated from what he argues is the flattening of the economic world through the processes of globalization. Friedman's new flat world is an equalized economic playing field that has been made possible through a combination of information and communication technologies and other countries' greater investment in their educational infrastructure. Yet the new flat economy is nothing to fear, Friedman asserts, since 'American individuals have nothing to worry about from a flat world—provided we roll up our sleeves, be ready to compete, get every individual to think about how he or she upgrades his or her educational skills, and keep investing in the secrets of the American sauce' (Friedman, 2005, p. 252). However Friedman's hopefulness is also tempered by his simultaneous recognition of US stagnation in key fields of knowledge production when compared to other nations that are quickly surpassing the US in areas such as biotechnological and biomedical R&D investment. China and India, according to Friedman's analysis, both have work forces that are more driven and better educationally prepared for the competitive flat economy that requires a high degree of technical proficiency, an unbridled work ethic, and innovative thinking. Friedman implores that such a growing accumulation of human capital in other parts of the world should be a wake-up call for US policy makers and corporate leaders alike. If the US wants to have any chance of retaining the mantle of economic and moral leader of the world, Friedman argues, its educational system must, in short order, remedy some of the structural flaws that are preventing the necessary amount of human capital from being produced. Put simply, the educational population within the US, according to Friedman's analysis, must be reconditioned for the new coordinates of the flat world—schools and universities being the most important places to begin such a reconstructive project.¹⁰

What Friedman's argument for a reinvestment in the human capital of the US's educational population ultimately purports is an equation that is pregnant with contradiction. Following the overall logic of Friedman's 'quiet crisis' argument to its resolution,

what becomes evident is a comparative choice that is far from desirable. That is, in pointing to countries such as China and India that are investing more into their educational populations as comparative models of productive life, Friedman fails to take into account how these examples are the result of neoliberal pressures that have been a large part of the formation of the landscape of global capitalism. In other words, what Friedman is in effect suggesting is that the laborer in China who works long hours in a massive transnational corporate factory assembling electrical switches or extracting valuable metals from e-waste sites that hold massive amounts of disposed computers and monitors, is the model of the motivated and innovative worker of the 21st century that the US should strive to emulate. Here workers' realities are strictly regimented through the tight organization and disciplining of worker groups in camp-like atmospheres where micromanaging for efficiency, quality control, and the extraction of value from both human and natural life is the dominant ethic.¹¹ Thus what Friedman's celebratory framing of flat world production and exchange circuits obscures is how valuable metals attached to control boards in computers and human life are both condensed into a similar form of valuation. In other words, an ethic of extraction rules the model of labor and production that Friedman points to as a competitive model from which the US should be taking its cue. From a biopolitical perspective, then, Friedman sets up a false choice that promotes a vital politics for the further destruction of life rather than forms of resistance that can lead to an alternative model of politics that jettisons this ethical component that the human capital theory harbors and in fact promotes.

Indeed, it is not surprising that Friedman is one of the central theoretical figures informing the RAGS document. As such, one of the top priorities identified in RAGS is to address the problem of how to produce 'an educated, innovative, motivated workforce—human capital— ... the most precious resource of any country in this new, flat world' that starts by dealing with the 'widespread concern about our K-12 science and mathematics education system, the foundation of that human capital in today's global economy' (RAGS, p. 30). In a strategic sense, RAGS identifies the critical shortage of human capital, or the 'disinvestment in the future', as being one of the most urgent problems facing the US economy and its national security. Reading this argument in the light of the promissory ethic that helps animate biocapitalism, the crisis Friedman, and by extension RAGS, has named can with little effort be reframed into the problem of how to extract greater amounts of human capital from an educational population that lacks the requisite vitality needed for a competitive, technologically and scientifically driven world.

In restating the problem in this way, we are in a better position to view one of the strategies RAGS forefronts for achieving the goal of maximizing human capital production via education, its '10,000 Teachers, 10 Million Minds' program. A plan built around a favorable economy of scale, its design principle rests on the simple formula of recruiting '10,000 science and mathematics teachers by awarding 4-year scholarships and thereby educating 10 million minds' (RAGS, p. 115).

What is apparent in the '10,000 Teachers, 10 Million Minds' approach is a distinct biopolitical project that underlies the science education reform movement writ large. Ranking this program as one of its most urgent, RAGS reveals its promissory framing in formulating the ultimate goal of the '10,000 Teachers, 10 Million Minds' program: 'our

country appears to have lost sight of the importance of scientific literacy for our citizens ... without basic scientific literacy, adults cannot participate effectively in a world increasingly shaped by science and technology' nor will there be a 'next generation of scientists and engineers who can address persistent national problems, including national and homeland security, healthcare, the provision of energy, the preservation of the environment, and the growth of the economy' (RAGS, p. 112). Here, in one of RAGS' top recommendations, is the simultaneous deployment of both the promissory valuation and national security tropes. Each, however, needs to be dealt with separately within the RAGS framework in order to fully assess how the project for defining scientific literacy has become fully entwined with the imperatives of biocapitalism. Specifically, how the goals of science education have been translated into ones that are in line with developing a type of educational vitality heavily invested with biocapitalist literacies.

Similar to the biotech start-up lab model, the '10,000 Teachers, 10 Million Minds' model conceives of schools not unlike the laboratories in which venture capitalists stake large amounts of capital in the hope of receiving large returns. What should also be recognized in the symmetry drawn here between the lab and school, however, is how the ethic of promissory valuation is shaping the way policy makers and corporate actors frame scientific literacy, and by extension the overall enterprise of public schooling as a site for extracting a more exchangeable biovalue from educational populations. Perhaps one of the clearest examples of the promissory value framework in action is in the '10,000 Teachers, 10 Million Minds' real world model: The Merck Institute for Science Education (MISE).

The merging of science education with one the largest pharmaceutical corporations in the world is not just another instance of increased privatization in the public education system, it also demonstrates how corporate actors have long recognized the importance of investing in education as a strategy for receiving increased value in return. The history of intimacy between educational institutions and scientifically driven industries is a long and well-documented one (Marcuse, 1964 [1991], 1972; Noble, 1997; Nowotny, Scott & Gibbons, 2004; Olssen & Peters, 2005; Cooper, 2009). But in the example of MISE a new strategic site of production has become apparent. In addition to continuing the practices associated with corporate-academic partnerships that use public funds and spaces for generating private gains, biocapitalism adds to this existing relationship in its targeting of teacher development as a promissory site of investment. Here the public and democratic function of teaching that at minimum is rhetorically connected to the legacy of the democratic public school system in the US has been completely replaced by a regime of biopower that has reconfigured democracy into something that is largely measured by living capital. By zeroing in on teacher development as a site of investment, the MISE program of the '10,000 Teachers, 10 Million Minds' approach only further advances the erosion of public spaces that could allow for alternative critical literacies of science and technology to develop in society. In essence, by affecting the means of production of science education with a promissory framework, what is ensured is a more exchangeable literacies and individuals for biocapitalist labor markets.

As a global leader in the pharmaceutical industry which produces such drugs as Vioxx and Propecia, Merck's active role in shaping science education policy, science education professional development, and standards-based assessment models goes well beyond the

pale of simple corporate citizenship. Instead, what we see in the instance of MISE as a proposed exemplary model for transforming scientific literacy into an extension of the logic of promissory investment is a powerful mechanism for shaping educational life. One of the most important ways the MISE teacher education and assessment program transfigures the act of education into a vitality technique is through the epistemic transfer that occurs in a science education context created and managed by biocapitalist actors.

In their effort to replenish scientific and technological human capital reservoirs Merck does not hide the fact that '[f]ostering the next generation of scientific leaders is a key part of Merck's overall commitment to science: It is essential for the sustainability of our business to have access to the best trained scientific minds globally, and it is essential for the economic development and well-being of the communities in which we operate'. Toward this end Merck has also 'provided long-term, sustained support for programs that expand capacity for training in biomedical and health sciences' (Merck, Sharp & Dohme Inc, 2009).¹² Residing in the epistemic transfer between a biocapitalist actor (Merck) and science education contexts is a clear example of what science study theorists have identified as 'the social' and 'the scientific' coproducing one another. As such, the epistemic structure coproduced in the knowledge-producing site of science teacher training program and biocapitalist entity is one that is designed to achieve the goal of 'hav[ing] access to the best trained scientific minds'. Again what rises to the surface is how promissory valuation, a principle attribute of biocapitalism, treats students (and teachers) as a strategic site in which to invest and extract particular kinds of biovalue.

Another important effect of the epistemic transfer between biotech industry and science education programs is the complete collapse of biocapitalist values into the milieu of education. By managing science education pipelines for teacher training and development, what is simultaneously foreclosed on is the potential for an alternative future where science education could mean more than what human capital as an educational goal can achieve. In other words, the struggle to determine the productive parameters of scientific literacy in educational contexts is also a struggle to control how individuals treat and understand life in our highly technological and scientific society. What is at stake in the science education reform movement and exemplified in the MISE model, therefore, is an educational life that is defined through biocapitalist progress, as opposed to one that calls such a productive model into question. Yet dislodging the narrative of progress tied to the biocapitalist concept of scientific literacy is difficult because it is also tied to a productive regime of national security strategies.

The second biopolitical aspect of the science education reform movement and its concept of scientific literacy I want to examine is what Foucault saw as one of neoliberal society's most pervasive qualities: risk management strategies. At the most general level, the salvatory trope operating in RAGS grows out of the view that US security in the post-9/11 era is inextricably tied to the endeavor of institutionalizing a mode of scientific literacy compatible with the demands of biocapital. The co-mingling of risk management strategies and science education stems from political and corporate architects who view science and math education reform as '[i]nvesting in science (including math and science education) [as] the most important strategic investment we make in continued American

leadership economically and militarily' (Gingrich, 2006). Helping construct this foreign policy component of science education is the widely held view that biocapitalist industries are the most important sector of the economy, and as such they cannot be understood outside of national security and market competition matrices. Perhaps nowhere can the salvatory mission tied to science education reform be seen better than in the Association of American Universities' *National Defense Education and Innovation Initiative* (NDEII), a strategy that RAGS heralds in its call for initiating security oriented reform through schooling.

The NDEII is a policy report created by the AAU to call attention to the security threat that a depleted pool of scientific and technological human capital represents to US stability. The coalescing of national security and economic health as it relates to the area of science and math education has a lengthy history in the US. Understood in this light, the NDEII report falls in historical line in its calling for a second coming of the original National Defense and Education Act that was passed in the aftermath of the Sputnik launch in the late 1950s. What is unique this time around, however, is how the ongoing war on terror and economic development driven by biotechnological advancement have collapsed so completely into one another that the project of education has become indiscernible from many of the national security goals of the US government in the post-9/11 era. However what is of particular interest to this analysis is the way the partnership between education and national security (a naturalized relationship in the reform movement) is given a heightened sense of urgency within the biocapitalist milieu that is shaping the behavior of both educational and military institutions in important ways. The synergy developed between education and security apparatuses in the biocapitalist context is clearly presented in NDEII's report: 'the principle ways to secure our nation's prosperity and military capability are to strengthen our educational system and revamp and re-energize the structures for innovation that have served this country so well for the past half century. The concern is clear: if we remain on our present course, our nation will not be able to produce the well trained scientific and technological work force necessary to meet increasing competition in world markets' (Association of American Universities, 2006).

The relationship between educational and security projects in a biocapitalist framework such as the NDEII and RAGS is clearly one that is playing out on a more complex plane than past iterations of science and math education reform in the US. That is, just as the claim that human capital in the areas of science and mathematics education are at threateningly low levels, a similar notion of security can be drawn that equates the ability of governments and corporations to expand zones of production and markets through the acquisition of raw biomaterials throughout the globe. As Cori Hayden has argued in her recent work on bioprospecting, the tension between multinational corporate patent rights, states, and local indigenous communities is only the front line of a larger battle for obtaining raw biomaterials that lucrative US biotechnological industries require to function and meet their future oriented demands. As Hayden puts it, 'these contracts [bioprospecting rights], which set up the chains of entitlement and access between drug companies and southern resource providers *via* academic scientists, points us to concerns that are not easily contained in the moniker "commodification"' (Hayden, 2003). In considering this neoimperial aspect of biocapitalism, I am

suggesting that any analysis that looks at how biocapitalism is shaping important trends in science education also needs to take into account how the trope of security is very much a two-sided coin: the domestic production of human capital in STEM areas of education and the neoimperial practice of acquiring and privatizing plant materials both share the same aim of extracting biovalue from life. Here the tethering of education to the project of national security within a biocapitalist model situates science education reform within broader networks of power that constitute the practice of technoscience within neoliberal global contexts.

On one end of the biopolitical spectrum, as I point out above, educational life within the matrix of biocapitalism is treated as a strategic site of production. This is largely the case because the development of technoscientific human capital is something that biocapitalism, as a mode of production and exchange, cannot exist without. Yet at the other end, life more generally is also integral to the growth of the bioeconomy, a model that stakeholders in government, the corporate world, and academia have a strong interest in expanding. In such a context plants in Mexico or human test subjects in India are also part of the formula for keeping the US secure and globally competitive in the new 'flat world' where education plays a key role. Thus, part of realizing how the biopolitics of science and math education operates is being able to interpret the one-dimensional framing of the 'quiet crisis' within a larger, multifaceted project that enlists educational subjects not only into productive sites for increasing technoscientific human capital, where individuals themselves are measured as biovalue, but also into participation in a predatory economic model that views forms of life as legitimate zones of production and exchange.

In a Foucauldian sense, I am suggesting that we must think of human capital education operating within the science education reform movement as both a disciplinary and control technology; the concept of scientific literacy being the most important technique of intervention that is aimed at both shaping individual habits and the general regulation of educational populations. With human capital as the ethical grounding for science education, students are trained into ways of thinking about *and* participating in scientific activity that is also part of a larger project of constructing a promissory future. The imaginary future built into the project of biocapitalism, however, is also dependent on the ability to manage and regulate educational populations by tying nationalistic and imperial goals to science education. With this in view, the biocapitalist project to define scientific literacy in educational contexts today signals the advent of a social milieu that has already 'pose[d] itself the problem of the improvement of its human capital in general' and answered 'the problem of control, screening, and improvement of the human capital of individuals, as a function of unions and consequent reproduction' (Foucault, 2008, p. 228). If this is indeed the case, and in fact this is what I am arguing, then human capital education—what constitutes the ontological basis of science education reform in the US—needs to be read within what Nikolas Rose has identified as one of the most prominent features of biopolitics today. Namely, how science education is directly linked to the 'the marketing powers of the pharmaceutical companies, the regulatory strategies of research ethics, drug licensing bodies committees and bioethics commissions, and, of course, the search for profits and shareholder value that such truths promise' (Rose, 2007, p. 28).

What is missing from the debate surrounding science education reform in the US therefore, and what my analysis points to, is a recognition of how scientific literacy is an integral component to a larger biocapitalist model geared toward controlling and managing the conditions of educational life in a number of powerful ways. The educational implications of such a way of conceiving scientific literacy are indeed manifold. In the final section, in an attempt to provisionally respond to the biocapitalist concept of scientific literacy examined above, I focus attention on the question of what an alternative biopolitical model of scientific literacy informed by a non-promissory and salvationalary value framework might look like. Put simply, I want to ask from where a life-affirming model of scientific literacy would begin, one that is guided by a notion of ‘vital politics’ concerned with ecological health and social justice, as opposed to one that carries with it an ethic oriented toward the capitalization of life.

Scientific Literacy and Biodemocracy

Developing a biodemocratic conception of scientific literacy should start with a strong understanding of the ways in which biocapitalism has fundamentally transformed traditional boundaries between culture and nature, human and nonhuman. As an economic and developmental model, biocapitalism involves culture and nature in countless efforts to enlarge areas of commodification, exchangeability, and consumption. Indeed, as STS theorists have pointed out, the era of politics at the molecular level is now upon us. It is no surprise then that science education has become a strategic target of intervention by corporate and governmental actors who are seeking to reconfigure educational life in ways that will best meet the needs of a fluid and highly competitive bioeconomy. The era of biocapitalism, in other words, presents students, teachers, and citizens with an entirely new terrain in which life is in a state of constant flux and reassembly: mental health, medical treatments and procedures, the genetic manipulation of biological processes, and reproductive technologies all represent a growing constellation of areas of human and natural life mediated by forces operating within the promissory and salvationalary calculus of biocapitalism. In such a context how should we begin to rethink scientific literacy given the fact that it has become one of the most utilized technologies of control for managing social futures in line with the promissory and salvationalary ethos of biocapitalism? One point of entry for exploring such a question is to look at the model of citizenship that has emerged in the era of biocapitalism and more precisely what this type of civic life means to the project of rethinking the intersection of democratic education and biopolitics.

In the binding pact created between scientific, corporate, and governmental and non-governmental actors that comprise the nexus of biocapital, a unique type of ‘biocitizenship’ has arisen that challenges traditional pedagogical considerations of civic life. As Rose has noted in his work, ‘biological citizenship’ is one of the most prominent features of twenty first century politics and signals a new era of vital politics (Rose, 2007). Rose’s concept of biological citizenship (which draws upon Paul Rabinow’s theory of biosociality) is based on a theory of subjectivity which conceptualizes individuals as ‘shap[ing] their relations with themselves in terms of a knowledge of their somatic individuality’ while also interpreting how ‘collectivities [are] formed around a

biological conception of a shared identity' (Rose, 2007, p. 134; Rabinow, 1996). Rose's notion of somatic politics, or a politics oriented toward the care of the body, is a useful starting point for thinking about the formation of subjectivities in science education environments that are increasingly being shaped through biocapitalist imperatives for a number of reasons.

By utilizing Rose's theory of biocitizenship, the dual formation of individuality and sociality as a point of reference, a pedagogy for civic life embedded in biocapitalist scientific literacy can be elucidated in a productive manner. As Rose has documented in his research on the bioeconomy, many countries are engaged in projects to educate their public about new biotechnological advances in such a way as to inscribe in the individual a sense of personal responsibility for developing biomedical literacies of health. This governmental strategy of placing the onus of collecting knowledge about potential health treatments for one's body on individuals is integral to the process of making biological citizens (Rose, 2007). However, such public pedagogies of self-care also rely on top-down models that involve 'the creation of persons with a certain kind of relation to themselves' (Rose, 2007, p. 140). For Rose, biological citizenship thus focuses largely on individuals' ability to develop literacies of health and possible treatment options that are shaped and influenced through a variety of corporate biomedical regimes. Underlying this biocapitalist model of citizenship is a type of civic life that is dependent on biomedical industries and mental health experts for interpreting the somatic lives of individuals.

In applying Rose's notion of biocitizenship to science education contexts, what becomes apparent is how scientific literacy infused with biocapitalist values implicates the body of the individual within not only the consumptive but *also* the productive domain of the bioeconomy. From this standpoint, Rose's theory of somatic politics that underlies his notion of biocitizenship can be extended in viewing science education as a form of biopower that involves the individual as a potential participant (or at minimum a tacit actor) in the very productive regimes defining biological citizenship. Even if individuals do not become active participants directly connected to sites of biocapital production such as biochemical laboratories, genomic research facilities, etc., they nonetheless indirectly accept a concept of citizenship that is involved in the consumptive and pedagogical patterns that the bioeconomy has set into place. In other words, this broader civic function implicit in the biocapitalist expression of scientific literacy normalizes the notion that life is something to be managed and controlled through technoscientific knowledge and practices. Thus the desire for technoscientific labor underlying science education reform both creates a type of political life (the subject who is educated into the acceptance of the investment/extraction ethic of biocapitalist society) and exchangeable forms of biomaterial (plant compounds, subjects highly invested with technoscientific know-how, genetic information, etc.) as the basis of scientific literacy—the most important tool for regulating public understandings of technoscience in society.

On this point Antonio Negri and Michael Hardt's biopolitical notion of immaterial labor is instructive. In their reformulation of the traditional Marxist concept of labor, Hardt and Negri persuasively argue that immaterial labor has become the affective skin of biopolitical production in late capitalist society. Data, codes, symbolic interpretation, affective communication, and information and communications technologies all comprise forms of immaterial labor that biopolitical production now largely rests according

to their analysis (Lazzarato, 1996; Hardt & Negri, 2000, 2004, 2009). Reinterpreting Rose's notion of biocitizenship as a model of vital politics alongside Hardt and Negri's notion of immaterial labor, however, helps bring to the surface a striking feature of the neo-Sputnik model of scientific literacy: its implicit ontological project of producing educational subjectivities attuned to the circuits of biocapital. Rethought from the standpoint of the production of individuality *and* sociality, what scientific literacy in a biocapitalist framework seeks to create is a pedagogical environment where individuals are indeed somatically defined but in a way that directly relates their bodies to forms of immaterial labor that fuel biocapitalist production—investment in human capital as a method for cultivating biocapital workers, that is, expands immaterial labor as a form of social power. Similar to Marx's analysis in *Capital* (volume 1) of how the capitalist mode of production turns industrial labor into a form of social power, immaterial labor (which is perhaps the most valuable type of human capital today), the productive base of biocapitalism, creates a social space where individuals' identities are heavily influenced by institutions and governmental/corporate entities that stand to profit most from particular configurations of immaterial labor.

Yet as Hardt and Negri's dialectical understanding of immaterial labor also suggests, such forms of labor that lend themselves to reconfiguration can also be a basis for multitudinal expressions of democratic resistance (Hardt & Negri, 2004). That is, as biocapitalism relies on forms of human capital that are highly invested in immaterial labor (deeply important to laboratory work for example), science education figures prominently in any alternative biopolitical project seeking to produce a different ground for educational life that is not measured by an extractive ethic. Thus, biocitizenship has taken on an added dimension through the biocapitalist expression of scientific literacy being promoted today. This new dimension emerges from the epistemic transfer that takes place through types of immaterial labor privileged by biocapitalism and science education in the neo-Sputnik era, which works from the understanding that life is a manageable and controllable field. Here a vital politics has indeed risen to prominence. It is on this axis, the recognition that 'life itself' has become the target of politics, that an alternative vital politics could be located in education.

In setting the concept of scientific literacy within the broader biocapitalist context as I have attempted to do above, the field of extractive biopower at work has become more discernable. But what biocapitalism has also done is to create a political context where it is increasingly difficult to bracket off the condition of human and natural life from the activity of science (or for that matter the activity of learning and teaching science). In other words, in making life one of the most valuable resources to production, biocapitalism has completely dissolved the modern myth of value neutrality that science has turned to time and again for retracting itself from politics. Buoyed by various technoscientific advances that have made it possible to extract value from life, the political stakes of the biocapitalist era can thus largely be seen as now resting firmly on biological grounds—science can no longer claim to solely operate in the realm of nature; it has in fact fused the natural and social into complex webs of power in the biocapitalist era. It is also in this space where an alternative scientific literacy could come into being that takes life as seriously as does the biocapitalist productive framework and the form of literacy it seeks to advance. Such a scientific literacy would need to focus on practices

that remove life from the promissory and salvatory value framework that underpins biocapitalism. Put differently, a biodemocratic articulation of scientific literacy would need to readjust somatic individuality and sociality in a way that promotes a non-extractive ethic through an alternative ontological zone of production. One possible way to produce such an educational space would be to link learning and teaching science to practices and social movements that are actively resistant to biocapitalist visions of the future, ones that represent cultural practices rooted in communities producing biodemocratic life.

One place to look for an alternative scientific literacy informing a biodemocratic practice is the GrowHaus urban farm and market in Denver, Colorado. Designed and implemented in what one of the co-organizers called a 'food desert', the GrowHaus urban farm focuses on local, healthy food production and distribution in a largely minority and working class neighborhood. Taking its cue from the food justice movement which seeks to extend sustainable and ecologically healthy life practices to all communities, the GrowHaus is a strong example of a counter-scientific literacy at work that rejects extractive ethics and instead is infused with one that works within and learns from natural and ecological limits.¹³ One of the marquee features of the GrowHaus, and what makes it unique amongst other urban gardens within the US, is its integration of an aquaponics system: a sustainable life cycle system that uses 'a recirculating process to grow and harvest plants, and farm fish' by using 'fish waste [which] works with the beneficial bacteria in gravel and plants, creating a recyclable, concentrated compost' (O'Connor, 2010). The GrowHaus represents a space where the science of life is linked to a politics of life in a way that affirms healthy and socially just communities as opposed to treating both as minable resources.

In the GrowHaus example there are at least two qualities that I suggest should help constitute an alternative scientific literacy that works from a different biopolitical framework. Much in the same way that Hardt and Negri discuss the use of immaterial labor for creating the skin or ontological ground of a multitudinal expression of democracy, the GrowHaus model reflects a practice of science rooted in a social and political problem; that is, knowledge and technology are utilized in a manner that promotes and respects the healthy limits to life while simultaneously addressing a structural problem within the community: access to healthy and sustainable sources of food.¹⁴ Secondly, the GrowHaus also exemplifies what Hardt and Negri see as the often neglected positive aspect of biopolitics that has the potential for 'the creation of new subjectivities that are presented at once as resistance and de-subjectification' (Hardt & Negri, 2009, pp. 58–59). The GrowHaus, interpreted as a positive biopolitical act, represents a productive zone of life in two senses: natural life in the form of plants, soil, fish, water, solar energy, and bacteria are coupled with a cultural practice of experimenting with alternative political options for growing and distributing food in a community that has structurally been denied access to non-industrial diets.

As a generative context for producing forms of biodemocratic scientific literacy, urban farms such as GrowHaus could potentially offer students and community members an opportunity to learn and participate in science within an ecosystem and social setting they are actively a part of creating. For example, from the aquaponics system utilized in the GrowHaus, part of a potential pedagogical experience could be based on a model of

science that recognizes how human and nonhuman actors are co-producers of science and thus social life. That is, along with their human counterparts, fish, plants, bacteria, and soil are explicit active participants in the production of a life-affirming scientific practice: fish create ammonia in their waste that bacteria consume and convert into nitrates that eventually become nitrogen which is used as plant food. In the series of chemical changes that occurs through the interaction between an aquaponics system and planting beds, a perfect example of learning scientific literacy from a situated context emerges. It is one that values and makes clear the connection between biological life processes and community health in a direct, non-abstracted manner. Thus in teaching a lesson on matter and energy for instance, part of the core curriculum for 7th and 8th grade science standards in most states in the US, the aquaponics system provides a potentially biodemocratic pedagogical example in this sense: both humans and nonhumans are taken into account in this social setting where science is playing a highly productive role in the health outcome of the community. Here biopolitics meets scientific practice in a very direct way.

The co-productive act at work here between nature and culture can therefore be read as operating with a life-affirming ethic as opposed to an extractive one. Finally, scientific literacy in the GrowHaus model is still very much oriented toward and engaged with life, but in a way that is defined by 'resistance and de-subjectification' as opposed to an extractive relationship. In short, the biopolitical circuit is reversed in the GrowHaus model of scientific and community praxis because the relationship between life and forms of biopower has been redefined along qualitatively different power relations.

In turning to biopolitical models such as the GrowHaus, educators, citizens, and scholars could find vibrant examples of scientific literacy that are not invested in treating human and nonhuman life as extractable values. From alternative frameworks like the GrowHaus and other multitudinal examples, a pragmatic hope can be extrapolated in that the true promise of our social future lies not in learning how to better invest in the circuits of biocapitalism, but instead in learning to create alternative biodemocratic practices that can cultivate autonomous scientific literacies rooted in the needs of communities and planetary health. The future, in other words, largely depends on changing the approach in education from those focused on getting the most *out* of life to ones that make the most *with* life.

Notes

1. See also Lewis' essay 'Biopolitical Utopianism in Educational Theory' (Lewis, 2007) where he approaches the utopian debate in education along biopolitical lines. Building on Foucault and Hardt and Negri, Lewis seeks here to rethink the notion of multitudinal democracy through the figure of John Dewey.
2. I am using the term technoscience to designate what Bruno Latour (1988) and Donna Haraway, among other science studies theorists, have argued is a conflation of science and technology into a fluid relationship of knowledge production. That is, contemporary science cannot be understood apart from the powerful technological tools that help bring new scientific 'discoveries' into existence. Put simply, without a computer and complex software programs the mapping of the human genome could not have occurred. Thus the conflation of technology with the activity of science suggests a synergetic relationship as opposed to traditional views of science (knowledge) and technology (application of knowledge).

3. With this said, I am also being careful not to rely solely on Marx's notion of labor. That is I am adopting Foucault's view that the human capital theory of labor developed by economic theorists at the University of Chicago in the late 1950s and 1960s is one that attempts to sidestep the classical Marxian notion of labor: labor as a form of social power that results from the temporal calculations of capitalist modes of production used for extracting surplus value from human work. It is on this point that I believe Foucault's critique of human capital theory of labor, that emphasizes how the processes of extending economic analysis into domains considered to be non-economic such as human and nonhuman life, goes beyond Marx in very fruitful ways (Foucault, 2008).
4. Alexander Sidorkin has pointed out elsewhere that the human capital theory of education is based on the erroneous assumption that more education equals higher lifetime income (Sidorkin, 2007). As a strategy to shift away from human capital education, Sidorkin focuses on student labor to disrupt the widely accepted notion that increased investment in education is the only answer. My analysis takes a very different line that focuses on the biopolitical implications of human capital education; that is, the form of and uses of life promoted within a biocapitalist educational context.
5. As Donna Haraway points out, Sarah Franklin's (1998) work on the emergence of genetic material as commodified streams of information was the first to identify how 'nature becomes biology, biology becomes genetics, and the whole is instrumentalized in particular forms' (Haraway, 1997, p. 134).
6. Foucault's analysis of neoliberalism in his 1978–79 Collège de France lectures also points out the active role in which states must take in creating the conditions for free market economics: 'There will not be the market game, which must be left free, and the domain in which the state begins to intervene, since the market, or rather pure competition, which is the essence of the market, can only appear if it is produced, and produced by an active governmentality' (Foucault, 2008, p. 121).
7. For example, in 2006 the Utah state legislature passed a funding initiative to form the 'revolutionary' state/academic partnership USTAR (The Utah Science and Technology Research initiative). Its goal is to 'invest in world-class innovation teams and research facilities at the University of Utah and Utah State University, to create novel technologies that are subsequently commercialized through new business ventures' that 'will produce new technologies in multi-billion dollar markets' and where '[i]nnovation focus areas include biomedical technology, brain medicine, energy, digital media, imaging technology, and nanotechnology' (available at <http://www.innovationutah.com/aboutustar.html>).
8. Nikolas Rose attributes the term 'biovalue' to Catherine Waldby who first coined the term in her research on how body parts and tissues of the dead are utilized in ways to enhance the vitality of the living (Waldby, 2000). For Rose 'biovalue' can also be used in more general terms to describe 'the value extracted from the vital properties of living processes' (Rose, 2007, p. 32). Vandana Shiva must also be seen as an early theorist of 'biovalue' in her groundbreaking work on bioprospecting and biopiracy. See for example Shiva, 1997 and 2005.
9. Friedman is by no means the sole theorist to make the claim that human capital education is a key site of crisis to focus on. Following in the footsteps of early US theorists of human capital Gary Becker and Jacob Mincer, Claudia Goldin and Lawrence Katz, two prominent Harvard economists, also rely heavily on a human capital argument in their highly influential book *The Race Between Education and Technology*. For Goldin and Katz the US's current slippage from global educational and economic leader can largely be explained through this formula: 'in the first half of the century, education raced ahead of technology, but later in the century, technology raced ahead of educational gains. The skill bias of technology did not change much across the century, nor did its rate of change. Rather, the sharp rise in inequality was largely due to an educational slowdown' (Goldin & Katz, 2008, p. 8). In their framework, investment in education and the development of greater amounts of human capital for a hungry biocapitalism is the solution presented for solving complex educational problems such as social inequality.

10. Friedman focuses on three 'dirty little secrets' of the US educational system that, in his estimate, are key sites where transformation must occur. The three secrets he identifies are (1) slipping production rates in science and engineering PhDs as compared to other countries such as China and India; (2) the decline of worker ambition (one Indian worker, according to Friedman, can do the work of three US workers) in the US; and (3) the growing overall education gap in the US that leads to low numbers of individuals who have the requisite skills and knowledge for the relatively sophisticated forms of labor the flattened world demands (Friedman, 2005).
11. See Jennifer Baichwal's excellent documentary film *Manufacturing Landscapes* (Baichwal, 2006) in which photographer Edward Bertynsky visually depicts the totality of neoliberalized forms of labor across the globe. This film is a strong counter example to Friedman's celebratory framing of other nation's work.
12. Biomaterials from the 'natural' world are not the only ones sought after in biocapitalist markets. As Amit Prasad brilliantly argues in his research on drug trials in India, test subjects for pharmaceutical drug companies' trials are a highly-desired commodity in the biomedical field (Prasad, 2009).
13. The GrowHaus has been influenced by food justice projects such as Will Allen's Milwaukee-based urban farms that focus on the production and distribution of healthy sustainable growing practices in marginalized communities. See <http://www.growingpower.org/> for a history of Allen's Growing Power organization.
14. See Richard Kahn's (2010) excellent work on multitudinal democracy and 'new science' in his discussion and analysis of the Shundahai Network's peace camp and traditional ecological knowledge.

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