Biotechnology Education: An Investigation of Corporate and Communal Science in the Classroom

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Dissertation submitted to the faculty of
Virginia Polytechnic Institute and State University
In partial fulfillment of the requirement for the degree of
Doctor of Philosophy in
Curriculum and Instruction

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May 5, 2006

Blacksburg, Virginia

Keywords: biotechnology education as corporate, public secondary school, science education, private secondary school, biotechnology education as communal, economy, rural education

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ABSTRACT

It is impossible to imagine our schools or community without framing such a view around a corporate structure. Money, capital, and economic stakeholders are all around us, building a corporate landscape that all members of the community must travel through in the course of their everyday lives. To suggest that education should be void of any type of economic influence would be to deny that a very important thread of our communities' tapestry exists.

As we look at the way that these education intentions move outside our own communities and connect us to other communities and the world, we see corporate education economics framed in either a global or communal perspective. A corporate science education perspective tends to treat science with strict positivism, and technology with hard determinism. Communal theories of science education view science as post-positivistic and technology with a softer determinism; as a result social implications emerge, and the science becomes more socially constructed. It supports the personal capital of all students, regardless of their view of science or technology. It allows students to "border cross" more easily so they can "scaffold" new science information onto previous learning.

This research consists of exploring how biotechnology education emerged within the state, how the resources intersected within a biotechnology conference and how teachers conceptualized biotechnology practices in their own classrooms. The researcher

pieced together a sketch of the history of how biotechnology curriculum arose in high school biology classes. The researcher also explored the hybrid nature of biotechnology resources such as an educational conference where teachers attend workshops and lectures. The practices of two teachers in a public high school and one in a private school setting were also analyzed.

Introduction

Rationale for the Study

There are actually two reasons that the researcher became interested in conducting research on the conceptualization of biotechnology. First, he hoped that the results of this study would add to science education literature in a way that would problematize corporate education theory. Secondly, as a teacher, he was interested in how his own conceptualization might affect his own classroom practices.

It is impossible to imagine our schools or community without framing such a view around a corporate structure. Money, capital, and economic stakeholders are all around us, building a corporate landscape that all members of the community must travel through in the course of their everyday lives. To suggest that education should be void of any type of economic influence would be to deny that a very important thread of our communities' tapestry exists. Even though it might be naive to imagine our schools as being free from the branching rhizomes of economic intentions, it is important to examine how teachers conceptualize in order to see what economic intentions do filter into the classroom and how those intentions might set up barriers for future success of our students.

As we look at the way that these corporate education intentions move outside our own communities and connect us to other communities and the world, we see corporate education economics framed in either a global or communal perspective. A corporate science education perspective tends to treat science with strict positivism, and technology with hard determinism. This perspective separates science from any social implications and treats it as reproducible in any place with similar outcomes. It also makes it much more supportive of corporate intentions, supporting a free market economy theory. Communal theories of science education view science as post-positivistic and technology with a softer determinism; as a result social implications emerge, and the science becomes more socially constructed. Scientific practices less reproducible in every setting no longer support economic intentions. It does, however, make science more readily understandable to members of the community because it supports the personal capital of all students, regardless of their view of science or technology. It allows students to "border cross" more easily so they can "scaffold" new science information onto previous learning.

Biotechnology certainly fits into an economic landscape. The goal of biotechnology is to solve biological problems usually involving the production of a product. When the final outcome of a scientific practice is a crystallized like biotechnology, it becomes easy to conceptualize it in a way that supports economic intentions. However, biotechnology is also an innovative type of science that has ethical and social implications at its very core. Consequentially, as these two opposing forces intersect in this scientific practice it becomes interesting to see which forces become dominant when biotechnology is conceptualized by members of the community.

Through this study the researcher hopes to develop strong connections between the use of biotechnology in a positivistic and deterministic manner – in short, with a global perspective and the subordination of students due to their social capital. A global economic view also supports stereotypical socio-economic hierarchal system of classification by emphasizing science as void of any social connection, and the loss of personal capital. Brantlinger (2003) suggests that teachers' economic worldviews will play an important part in how teachers see their students and conceptualize science for their students.

Communities can be defined as places which are made up of people with shared experiences (Davis, 2001). The more shared points of interest there are within a community, the more likely members of that community are to come together and exchange ideas (Dewey, 1916/1966). More shared points of interest and exchanged ideas will increase the social capital of all students. Teachers who treat science in a way that supports a communal view of science education will most likely see all students as able to gain social capital. These teachers' practices can be categorized as fitting under the umbrella of social constructivism, which see science teaching as a human and social activity incorporating social tools "within institutional and cultural frameworks" (Lemke, 2001, p. 296). Communal science education does not solely subscribe to theories that conceptualizing teaching practices as representative of local responses to global economic needs as Carter (2005) suggests is a growing concern among educational.

The second interest in this study stemmed from the researcher's own interest in biotechnology and how it became an educational force. The researcher began to teach Advanced Placement Biology about the same time that teachers throughout the state were looking for biotechnology resources. He had an opportunity to examine how a biotechnology center emerged in this area of the state and how teachers co-constructed biotechnology resources with them. As a graduate student, a teacher leadership experience with a biotechnology center, the researcher was in a good position to examine how all members of the biotechnology community interrelated. As with all dissertations, this research has been reflective for the researcher as well. He has had the opportunity to examine his own teaching practices in the classroom in relation to biotechnology and its use. Hopefully the results of this research can not only contribute to the body of research on corporate science education, but can also add to another growing body of research on democratic classroom teaching practices.

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Chapter One - Conceptual Framework

Introduction

It is important for the reader to understand the dichotomy between corporate and communal science education as defined by the researcher. In order to support more fully the theoretical tenets of this study, the researcher will draw somewhat generalized definitions of what both “corporate” and “communal” mean and how they relate to the conceptualization of biotechnology by teachers who use it. In this research, corporate science education evokes a consolidation of power within an economic structure. This would be best defined as a type of science that is reproducible, perceived as value-free, and most likely to support global usage, as this type of perceived science can be deconstructed and reassembled in multiple settings with identical outcomes. In contrast, communal-based science education tends to be more democratic in nature. This perspective sees science as value-laden, somewhat post-positivistic and tends to embrace opportunities to utilize student inquiry as a pedagogical instrument. This leads to the student having more voice in how biotechnology may be used, either in the curriculum or in the community. It is a type of science that leads to explicit border crossings for marginalized students and community members, which evokes fuller participation by students and teachers.

Science Education as Corporate

The corporate influence permeates not only schools and education, but also many ways that define science and how scientists see themselves and their practices. According to Barton (2001), “more and more these days, capitalism and science are moving into shared orbits” (p. 851). As capitalism and science share orbits, they affect each other. Corporate influences tend to view scientific thought as more positivistic in nature, and technology as more deterministic. In turn, a corporate environment finds allies in the community through reproducible and value-neutral cultural tools.

Nature of science: positivism. Research on how scientific thought emerges from corporate stakeholders evokes question on what is the nature of science itself. Traditional science, whether it emerges from a corporate or a public space, finds its epistemological moorings in strict positivism. It emphasizes the tenets of objectivism and linear scientific practices, and is characterized by its use of objectivism in order to support an overall realist or positivist epistemology of the field (Johansen, 1991). By supporting a positivistic type of scientific knowledge and deterministic technology, a corporate influence can remove any social interactions with scientific thoughts and ideas. This type of science and technology becomes much more static, more reproducible, and ultimately can more easily support a capitalistic environment.

Positivism maintains its objectivity in two ways. First, it maintains objectivity through the universal application of the scientific method. Western science emphasizes inquiry procedures such as a strict adherence to the hypothetico-deductive method of reasoning. The ability of the scientific method to be a representative form of understanding for all discovery experiences is a cornerstone of theory-law based ideology. Traditional science also maintains objectivity through the selectivity of scientific practices. A linear chain of scientific practices, through context and discovery**,** is strictly followed.

Secondly, positivism relegates knowledge as a stable property of objects that are knowable and unchanging (Johansen, 1991). Objects have meaning and impart knowledge in the relationship between the learner and the real world. This theory holds the metaphysical assumption that the world is real and ordered and a learner can appropriate this order. In this way, knowledge represents a real world that is separate from the learner.

Throughout time, many philosophers and scientists have attempted to make a clear disconnection between what is thought of as a scientific practices and what is thought of as the social negotiations of science. By creating boundaries between science and other forms of knowledge, Popper (1985) have helped develop a strict compartmentalization of both scientific thought and practice. Slowly, the theory of positivism crystallized into a universal scientific worldview. With an emphasis on objectivity, linear practices and theory development based on falsifiability rather than verifiability, science emerges as a type of knowledge that is characterized by logical reasoning, a static nature of reality, and the generation of theories that produce testable data (Wong, 2002). The social practices that go into the generation of such knowledge forge into a universal worldview that stresses positivistic forms of science.

Positivistic forces would like to see biotechnology as close to what Bowker and Starr (1999) refer to as a boundary object or a "durable arrangement among communities of practice" (p. 297). They would prefer to take the crystallized social practices of biotechnology labs and arrange them into a practice that can be seen in similar ways to different communities. By doing so, they can control how biotechnology travels to the public by developing single-voiced protocols and materials that support their idea of biotechnology. Produced in a micro-climate such as a lab and usually developed for a product, the corporate and positivistic influences tend to diminish the social nature of the scientific practice. What emerges is a static view of biotechnology, albeit one that can be easily packaged and moved from one space to another.

Technology and determinism. Because so many of the objects used in biotechnology are indeed technological, a brief summary on the theoretical background that frames the usage of biotechnology in a global perspective is helpful. As any other evolving form of artifact in the classroom or social environment, Callahan (1962) states that when communities use technology in ways that promote a free market economy, technology's use does promote more stabilized forms of technology knowledge and practices.

Technology, like any other element of curriculum design, can be implemented in a way that simply magnifies the technical knowledge of the scientific investigation, or it can be used to elevate it to a level where students are critically thinking about how the technology is placed within a community. A universal corporate scientific worldview blocks the practice and production of science from certain members of a community by removing any social aspect from the technology that is used to produce the science. It then creates a stable definition for the technology that can be appropriated by a universal worldview. Lemke (2001) explains:

> The most sophisticated view of knowledge available to us today says that it is a falsification of the nature of science to teach concepts outside of their social, economic, historical and technological contexts (p. 300).

Mackenzie & Wacjum (2000) refer to technological determinism as the strict use of technology in order to produce technical knowledge that supports a positivistic science. This emphasizes a strict use of objectivism and scientific experimentation for the production of scientific facts that supports a universal worldview. In the traditional science ecology, technology assumes the corporeal embodiment of this rational inquiry. Technology is viewed with a deterministic approach, emphasizing an independence of the relationship between actors within a network in any given moment. This creates boundaries that help network builders stabilize practices.

When Science, Technology and Society (STS) instruction is used in conjunction with an artifact in an objectivist manner – one not assuming that science and technology are interwoven in a community – the science teacher runs the risk of assuming a harder deterministic perspective (Mackenzie and Wacjum, 2000). With this perspective, the technology can be situated as value-neutral while incorporating the capitalistic and possibly hegemonic intentions of the scientific worldview. Students with different worldviews will most likely have different trajectories with technology. If these trajectories are so different from the stable representation of the technology of the time, then the student may not be able to border cross effectively, even with the aid the technology.

Influence of positivism and determinism. In order to see how positivism and determinism remain intact within a community of practice, it is important to understand how corporate metaphors help develop economic theories that support corporate educational intentions. Undoubtedly, over the last several decades, no other sector of public life has influenced the educational landscape as much as the business sector. However, the intersections between the corporate and educational worlds have not always served educational democracy alone. Historically, the business sector has always had a vested interest in the way teachers educate their students, and therefore has had a remarkable influence over educational policy. Such pressures became supercharged during the 1980s with the introduction of reform documents like *Project 2001*: *A Nation at Risk,* culminating with the current movement of No Child Left Behind. Since political agendas like these have linked the success of the economy to a particular type of curriculum and pedagogy, the corporate sector has positioned itself as a stakeholder in the educational process. They can do so with the use of corporate metaphors.

Corporate metaphors. In order to trace the development of such a close link between the corporate and educational worlds, Callahan (1962) deconstructs some of the processes that allow such new corporate links to be formed. One way that business can forge this new relationship and place itself as an educational stakeholder in the eyes of the public is to look at how the corporate metaphor has emerged in science education practices.

A corporate metaphor is a linguistic tool by which the business sector can link its own practices to those in educational sphere; these corporate metaphors are prevalent in the educational discourse. The corporate world has constructed the social category and links the outcomes of educational practices to those of a free market economy. These industrial metaphors are one way to keep this new connection. Callahan (1962) suggests these metaphors arose in the educational system of the United States around the turn of the century. He explains that as the economy grew at immense speed and depth through the help of industrial leaders like Henry Ford, so did the cultural and symbolic capital of industry. However, budgets for education did not grow at the same rate.

School leaders soon adopted a corporate discourse, observing that the industrial methods were successful in the business workplace; school boards were made up of business leaders and administrative jobs were dependent on the successful outcomes of teaching practices. Taylorism, a methodology of business efficiency, soon became the framework for many educational reforms. Such reforms saw students as products; and practices to teach students could then be easily measured by Tayloristic methods. Learning could be deconstructed into a linear sequence of teachers' work, which could be managed by efficiency experts. The industrial metaphor changed the educational landscape into a workplace that mimicked most factories of the day. The teacher was perceived as a nondescript worker, usually female**,** lacking individuality or much cultural capital, part of a mobile and temporary workforce. In turn, the administrator took the role of the businessman, mostly male and retaining more cultural capital, with the power of moving to higher administrative positions.

The industrial metaphor changed curriculum in a way that emphasized detailed learning objectives with measurable outcomes for each. Dewey (1916/1966) would suggest the nationalistic intentions of corporate stakeholders initiated the idea of behavioral objectives and competency-based education among others educational ideologies. When the industrial metaphor is used, then and today, it suggests a conduit model of education, where students are seen as empty vessels, plastic enough to be molded by teachers accountable to a watchful administration. It also defines teachers as extended workers supporting the economic initiatives of these stakeholders.

Economic theories. There are several current economic theories that evoked emphasis on industrial metaphors in the educational experience. First, to see students as empty and malleable, with teachers as distributors of education that will better serve student in the workplace, evokes an idea of the human capital theory. The human capital theory suggests that if a population is better educated, then the population will find it easier to find jobs and will be better able to serve the business world in meeting corporate goals. This, in turn, will lead to economic success. Even though experts have found over the last two decades instances where the economy continued to grow while education was still measured globally to be substandard, the industrial metaphor is deeply entrenched in the educational landscape.

Another theory evoked by the industrial metaphor is free market capitalism. In fact, it is the free market theory that justifies any work or workforce as being controlled by a political stakeholder, and therefore gives easy access by business into the educational arena. Free market capitalism, according to McLaren, suggests that the marketplace is the best way in which to organize society, because it allows all members to pursue their self-interests (Barton, 2001). Supporters of this theory usually continue the theory into other areas of society, including schools.

Governmental policies usually stifle a free marketplace and, therefore, are not friendly to business. Here corporate stakeholders will try to circumvent governmental control by privatization. Coinciding with a push for standardized educational reforms in the last two decades has been the push for school vouchers and funding for private schools. By privatizing the educational systems, the corporate stakeholders can intervene between the government and parents. Parents can choose the school that best fits their intentions for their child without the hindrance of that school's having to meet certain requirements by the government. Slowly, parents' intentions will dictate curriculum and, ultimately, which schools survive and which do not. The marketplace takes the responsibility of the government in regulating education policy. Dewey reminds us:

> Rulers are simply interested in such training as will make their subjects better tools for their own intentions. Even the subsidy by rulers of privately conducted schools must be carefully safeguarded. For the rulers' interest in the welfare of their own nation instead of in what is best for humanity, will make them, if they give money for the schools, wish to draw their plans (p. 95).

A broader question emerges from corporate education: If parents and community want children to be successful in the future, and since many of these students will enter the workforce on some level, why does the intersection of corporate and educational worlds seem so problematic? It does indeed present problems when one considers how the free market economy, and the human capital theory – the elements that forge many connections between business and the classroom – looks at a narrow educational aim. In many cases, a free market economy leads to excess resources for some and inequalities in resources for many.

Free market critics suggest that such a theory leads to the privatization of schools, which, in turn, further separates those who have resources from those who do not. In a time when the science classroom is becoming more diverse, corporate education needs to find ways to open doors to full participation for all students, not restrict them.

Economic theories and social hierarchies. There is no doubt that corporate metaphors and economic theories play an important part in defining social hierarchy in our communities today. No longer is a free market economy constrained by the physical and communicative barriers of geography. Both worker and consumer bases are expanding at a rapid pace. With this comes a widening diversity in members of the community and their hierarchy within a social class system (Brantlinger, 2003; Anyon, 1980; Sleeter, 2000).

Brantlinger (2003) found that the social class hierarchy of teachers and students may impact stratification of students or social status in the classroom. She discusses how a teacher's role, as defined by this classification systems, will in many cases determine how social class will be defined within the classroom. Brantlinger describes several ways to classify social class influenced by the five-tiered level by Anyon (1980); however, she develops three groups of participants from her research – "already there," "upward strivers" and "in-the-middle" (p. 81). Each group was categorized by similar thoughts and actions according to the conceptualizations of social class, both for students and teachers.

"Already there" teachers are those who emphasized schools as a place where people can achieve. This etiology denotes superiority because it suggests that students are basically the same, and if they are not successful, it is because of themselves – not including the environment or other social elements.

"Upward strivers" are those teachers who may not have had a good experience in school on their own; Brantlinger (2003) suggests that they continued in education because of people like their teachers who urged them along. "Upward strivers" usually talk about having lowly socio-economic beginnings, but were recognized by someone in the educational system as being talented or as having the intelligence and potential to be successful.

The "already there" and "upward strivers" spoke about having high achievement aspirations for their own students in the Brantlinger (2003) study. They were also the two groups of teachers who would not complain about current educational elements.

"In-the-middle" teachers are those whose family background, educational histories and current income match closely what Anyon (1980) suggests would be middle class. They are not defensive about inequalities in their working systems. Unlike the "already there" and "upward strivers" teachers, the "in-the-middle" teachers spoke humbly about success they had in school. More importantly to this study, these teachers spoke about behaving well in school. Although they may not have achieved the recognition and success of the other two groups of teachers, they focused on the idea that they got where they are today because their behavior allowed them access to opportunities that others were granted, possibly because of academic achievement.

In the Brantlinger (2003) study, "in-the-middle" teachers differed in educational opinions from those of "already there" and "upward strivers" groups most likely because "in-the-middle" teachers "did not see competitively high academic achievement as either possible for their students or as a likely avenue to social mobility for them" (p. 85).

When Brantlinger (2003) suggests that schools are "meritocracies" (p. 1), she alludes to the fact that many students are accessed or rewarded for such things as academic ability or work ethic. Each one of these outcomes can be measured in a way that treats learning in a positivistic manner. By treating education in a positivistic manner, such a hierarchy will place students in positions that support a free market economy and therefore the corporate intentions of stakeholders.

Science Education as Community-based

Whereas global science education reinforces a free market economy, positivism and determinism, the reproducibility of ideas and practices, and possibly social hierarchies, communal science education reinforces a more individual or community-based experience with science and technology. It strives to connect the social aspect of our communities with scientific practices. It does not see science as value-neutral or deterministic, but sees science as being constructed by social forces and the use of technology as a community effort.

Latour, biotechnology and the language game. Roth and Lawless (2002) remind us that over the past two decades there has been recognition that science is a form of culture and therefore can be considered a community. Even though within this community, scientists may have multiple ways in which they think of science; learning science “amounts to the participation in the particular practices of this culture” (Glasson and Bentley, 2000, p. 368). Traditionally somewhat static in their sense of the nature of science, scientists, like teachers, have seen their private sphere within the community embrace capitalism as well: “As science becomes more and more transdisciplinary… the natural and social sciences [incorporate] human resources” (Hurd, 2002, p. 5). Scientists must also enter a realm that is somewhat foreign to them as they navigate funding and grants. As “capitalism and science move into shared orbits” (Barton, 2001, p. 851), the community sees the emergence of corporate science.

Remembering that an overall goal of scientists and teachers is to create the fullest access and participation, Lave and Wegner (1991) suggest that there are many barriers and boundaries in the field of science which prohibiting people from moving from the role of novice to that of full participants. Davis (2001) continues by suggesting that forms of capital, which are necessary for community members to enter the field of science, serve as a barrier.

Latour's observes that in many cases "language games" do not move from one space to another intact. Without the constant supportive factors by multiple influences that present an image of science as positivistic, the corporate message of the science does not get translated verbatim while affecting community perception. Jones (2000) describes Monsanto's attempt to stabilize and control scientific thoughts; in this case, the knowledge surrounding Bovine Growth Hormone (BGH) in Canada. In their attempts to control scientific thought, Monsanto produced a scientific practice that was economically lucrative to some; however this generated a discourse in the political arena to control biotechnology, which ultimately failed. The industrial image of BGH changed as it moved from the private sector of Monsanto's laboratories to the community.

The Deweyan idea. To Dewey (1916/1966), the democratic ideal includes two important features. First, he sees a need for members of the educational community to have more varied points of shared interests, and secondly, he sees a need for recognition of mutual interests as a way to produce social change (p. 87). He believes that the second feature is the key to more free interaction with other social groups as well as to changing social habits by having to negotiate constantly with these different groups.

To the science teacher, these shared interests and values between elements of stakeholders and the educational community emphasize full, active participation in classroom science activities for students, regardless of worldview or life experience. "In order to have a large number of values in common, all the members of the group must have an equitable opportunity to receive and to take from others" (Dewey, 1916/1966, p.

84). This means that the educational resources that stakeholders provide must elicit active learning for all students. They must not be arranged in a way that emphasizes scientific concepts only. By isolating the social world from concepts, corporate stakeholders must emphasize scientific concepts only. Dewey states, “Isolation makes for rigidity and formal institutionalizing of life for static and selfish ideals within the group” (p. 86). By emphasizing concepts only, corporate educational influence will already be developing static organizational and classification schema of information for students. Students need only to apply such arrangements to the real world. In this way, stakeholders, by influence of resources for the classroom, determine the way students should think about scientific concepts, removing any “active” learning from the curriculum, as well as removing access to such information (and thus, any emancipatory potential from the learning experience.) Such schema may represent short-term stakeholder goals alone and will not include student desires.

For scientists, this view of science can be problematic because many have been brought up in the tradition of science as being positivistic, truthful and value-neutral. However, the different memberships that a person can hold within the community can make a strong connection between Dewey’s thoughts on the individual educational experience and the community. Dewey’s theories suggest that memberships and roles that a person holds within the community can greatly enhance a person’s opportunity to gain shared experiences with others and therefore have a voice in how education develops.

Lying in stark contrast to the strict scientific positivism that permeates a classroom via a corporate influence is the Deweyan sense of the individual’s learning experience and ideas. Where positivism emphasizes strict concept-driven science curriculum and pedagogy, the Deweyan sense of the democratic classroom consists of ideas rather than concepts (Wong, 2002, p. 324). To Wong, concepts are usually developed around certain representations or thoughts about the realistic or rational world. Cognitive activity is then the "mind's mediation between a person and the world" (p. 324). However, Dewey's ideas of learning center around experiences which exist in reality. To remove the world from the cognitive experience is to establish a set of categories or schema that students must scaffold in order to make sense of the concept. Whereas concepts are based on the categorization of thoughts by others, ideas are based on the active practice of applying science in the social world. Wong argues that although concepts are things that students learn and apply to the natural world, ideas require active learning on the part of the student and are therefore transformational for the student. The event of an idea emphasizes anticipation and motivates the students to move forward in the investigation.

In contrast to the type of science and technology that emerges from scientific spaces like a biotechnology center, philosophers, sociologists and practitioners of science scrutinize many of the rigid tenets that characterize positivistic science and deterministic technology. Although there is no clear consensus from philosophers of science as to what is the nature of science, Lederman (1999) suggests that there are several essential concepts regarding the very natures of science important for K-12 teachers:

> Scientific knowledge is tentative (subject to change), empirically based on or derived from observations of the natural world, subjective (theory-laden), necessarily involves human inference, imagination and creativity,

> necessarily involves a combination of observations and inferences and is socially and culturally embedded (p. 917).

Research into the history and nature of science is rich with evidence that scientists themselves have multiple ways in which they think about their own research, and that their personal worldviews do affect how they practice science. Research collected by a variety of science education researchers (Glasson & Bentley, 2000; Biaglioli, 1999; Gooding, Pinch and Shaffer, 1989; Lynch, 1985; and Latour & Woolgar, 1979) clearly finds evidence that there are many ways that scientists think and write about their work within the larger scientific community. Warren et al. (2001) explain:

> [These] studies, in their detailed analysis of the everyday work and talk of scientists, support a greatly expanded view of scientific practice, one which goes beyond emphasis of hypothetico-deductive reasoning and theory-building, everyday experience as a form of misconception, and informal language as inadequate to the task of precise description, explanation, and modeling (p. 532).

The fact that scientists do not adhere strictly to one way of thinking when practicing science would suggest that multiple worldviews do play a part in how scientific practices are seen within the community and may suggest how members of the corporate, scientific and public sectors solve problems and observe natural phenomena. This, in turn, supports a more social scientific approach to the nature of science, seeing science that is inextricably linked to the community in which it emerges and not simply a value-neutral tool to be used by network stakeholders to create new assemblages.

This socio-scientific view of the nature of science supports the theories of Wong (2002), who believes that students can experience success in both the affective and cognitive realm through powerful ideas. However, to ensure that ideas are presented in a way that they become open to all students, regardless of background or life experiences, the educational idea should connect concepts to the social by eliciting the fullest participation from students. It is only through this vibrant connection between the action of doing science and mental scaffolding of scientific concepts that an “amalgamation of action, feeling and thought” will occur (p. 324). To both Wong and Dewey, it is only here through this amalgamation that true learning exists. This amalgamation can exist only where science is viewed in multiple ways and not as a universal canon used to support stakeholders’ intentions.

When one examines closely the nature of scientific practice, objectivity, through linear and humanistic scientific methods, is determined by the scientific community. In this way, science is a socially-constructed network of like practices (Lave & Wegner, 1991). Objectivism develops within a community through stabilization of social practices while legitimizing scientific facts. Facts are created by political and rhetorical social practices of scientists in order to give the facts more grounding.

Now having what the network of science would consider neutral objective facts, the network constructs a way to remove further observations from the fact’s social moorings by creating a way to talk about the facts. In laboratory life (1979), Latour and Woolgar discuss how scientific facts are not discovered but are, in fact, constructed through the day-to-day social experiences in the lab. They describe how facts only receive their status when words are attached to them. In this way, scientists create facts.

To Latour and Woolgar, scientists do not discover facts about an independent world, but rather scientists impose order and disorder in a type of strategy game.

Lynch & Jordan (2000) explore how scientists crystallize laboratory practices when manipulating DNA sequences during a PCR (polymerase chain reaction) procedure. Evidence suggests that laboratory practices are crystallized within a community of practice and even, though scientists may adhere to the rigid and static confines of the traditional science canon, scientists incorporate everyday knowledge and multiple views when actually "doing science."

Worldviews and cognitive scaffolding. Students, teachers, and, in fact, all of us, live within different groups of human activity. These groups are almost always categorized into certain social organizations, such as families, churches, schools and other institutions. Lemke (2001) states that "our lives within these institutions and their associated communities give us tools for making sense of and to those around us: language, pictorial conventions, belief systems, value systems, and specialized discourses and practices" (p. 296). It is these social institutions which make up the tools that people use when observing and interacting with the natural world. These tools inclusively make up an individual's worldview. To the social constructivist, these tools, intersecting in each person, provide a unique way of exploring new experiences, storing prior knowledge and interacting with varied social environments.

Worldviews affect not only how people observe the natural world, but also how they make sense of it. The way that students and teachers perceive new information and integrate it into their own working knowledge would be considered cognitive scaffolding. As an epistemological construct, cognitive scaffolding can be described as the mental interplay between the abilities of the teachers and students when introduced to new information (Flick, 1995; Palincsar, 1986).

Roth (1995) suggests a schema theory of cognitive scaffolding when students and teachers are introduced to new information. In this theory, learners receive information for which they have some type of prior knowledge. The learners must activate this prior knowledge in order to make changes in the cognitive frameworks already established. When activating this prior knowledge, learners also activate a rearrangement of the sense-making tools that they have received from their communities. In this way, the learners' worldviews affect how new information becomes connected with already existing cognitive frameworks. In constructivist theory, this cognitive re-framing of mental scaffolds explains why many learners have greater success when learning is developed around prior knowledge investigations, or why some learners have difficulty refuting misconceptions, as these are fixed rather strongly into a mental schema that is supported by learners' worldviews.

Because teachers' and students' worldviews will affect how they use biotechnology and make sense of it through cognitive scaffolding, the definition of worldview can be broadened. Worldview is described by Kearney (1984) as "a culturally organized macrothought" (p. 1) and by Wallace (1970) as "the very skeleton of concrete cognitive assumptions on which the flesh of customary behavior is hung" (p. 143). Both of these definitions of worldview include the cognitive element of scaffolding. Cobern (1995) ties both the mental schema and socially implicit nature of a worldview with the idea that worldview is a "culturally-dependent, implicit fundamental organization of the mind…composed of presuppositions or assumptions" (p. 4). Furthermore, "[I]t is a set of principles or presuppositions that exerts broad influences over one's thinking" (Cobern, Gibson and Underwood, 1999, p. 542).

Worldviews and communities. Not only is a collective worldview individualistic in nature, it is also "typical of the people who have led lives like ours" (Lemke, 2001, p. 297). Worldviews are plastic in the sense that they travel along a spectrum from the individualistic to communal, shared experience. Lemke (2001) states;

> Every community is heterogeneous, and no individual learns and enacts all the roles in an institution. Cultures articulate across diverse sub-communities; they are never uniform or universally shared in their entirety among all or even most members (p. 297).

People from different sub-communities such as people of like race, gender or socio-economics may share a similar worldview. The communal tools like belief systems, value systems, and membership in organizations may be similar, and these people may have shared experiences that will shape how they interpret the world around them.

Davis (2001) describes a community as a "social arena with limits defined by the capital – cultural, social, economic and symbolic – that is valued and needed for individuals to legitimately participate within it" (p. 369). Members of a community share each type of capital with different sub-communities according to their affiliation. Davis (2001) suggests the roles people play within a community or network are linked to their personal capital. Personal capital would be made up of cultural capital or "primary legitimate knowledge" as determined by a group (Jenkins, 1992, p. 85). Here, knowledge is not only an individual experience but is shaped by the individual's community. The economic, social, and symbolic capital gained by belonging and practicing a task within a community, all lead to interpersonal relationships between members of a community and influence shared experiences.

To be a part of a community assumes a certain amount of active participation in the practices of that community as well as adhering to certain standards developed by members of that community (Lave & Wenger, 1991). This is supported by Latour's (1999) theory of relativistic realism. In this theory, Latour suggests that even though social constructivists might want to hold onto a strict philosophical relativism when discussing how the field of science crystallizes truths, there may be elements of truth that members of different communities may be able to identify. Latour suggests that knowledge is based in a somewhat static sense of reality, making it malleable enough for many different communities to use. Latour maintains a flexible form of realism by adopting science as a bridge between knowledge and the outside world, recognizing linguistic steps between knowledge and society. In this way, Latour sets up a philosophical principle that Lave and Wenger can use as an epistemological understanding of the development of standards by a group and how the production of these standards forces outsiders to accept knowledge produced by the group.

The roles that people assume within a community are linked to the amount of capital that a person obtains and how that locates that person within the network of the community. In order for members of a community to gain power or mobility, Davis also states that they "acquire capital, produce and reproduce knowledge through practiced and social interactions, increase their decision-making power and better the community and its members" (p. 369). Davis suggests that the beliefs and values that members hold not only represent a particular worldview but are also directly related to the capital that they have acquired or may have access to. This influences the positions members may hold within the community. The type of capital people acquire will determine what kind of experiences they will share within communities. These shared experiences, in turn, will help determine what type of worldview people may develop.

Participating within the community of science has a great advantage as far as acquiring capital and an identity that is valued by that community (Davis, 2001; Lave & Wenger, 1991). Participation in scientific activities with members of that community, who already hold capital, allows the novice to appropriate capital for himself through association. Davis (2001) asserts that one can acquire valuable capital by admittance to science coursework or programs, mentoring under an experienced researcher in a laboratory, communication with other scientists, reading and publishing research in a professional community and attending scientific conferences (p. 370). Also, by participating in a scientific community, a novice acquires a social identity – how others see people and also how people view themselves (Davis, 2001; Lave & Wenger, 1991).

There is research that suggests that when the worldview of a student and that of a universal scientific worldview do not match, there are ways in which the student will respond in order to attempt to gain capital and access into scientific practice in the classroom (Aikenhead and Jedgede, 1999; Lee, 1999; Costa, 1995). Students have trouble activating and changing their prior knowledge if their worldview and the worldview of science are too different. Lee (1999) quotes the National Science Education Standards or (NSES) from the National Research Council (1996) as stating, "Explanations on how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, or authority, may be personally useful and socially relevant, but they are not scientific" (p. 20). Having a narrow view of what science is may inhibit students' abilities to scaffold new concepts onto an older one when interpreting new information. In essence, this scientific view acts as another micro-culture that students must enter from their personal worldview. In many cases, this border crossing into different cultures is a hazardous one for many students, because many students find no points of shared experiences within the scientific content on which to scaffold new information.

If the cognitive frameworks of the individual are too different from new information, students have a harder time assimilating the newer ideas within existing information. In essence, the corporate scientific worldview acts as another micro-culture to which students must enter from their personal worldview when learning science. In many cases, this "border crossing" into different cultures is too foreign and difficult.

Border crossing research. Aikenhead and Jedgede (1999) state, "Science students are expected to construct scientific concepts meaningfully even when those concepts conflict with indigenous norms, values, beliefs, expectations, and conventional actions of students' life-worlds" (p. 270). Students and scientists are able to move cognitively from one sphere of context to another through a process called border crossing. Aikenhead and Jedgede build on work by Costa (1995), who developed four categories for students' ability to make transitions between micro-cultures. Those students who make smooth transitions between micro-cultures are termed "Potential Scientists." This category may include only about 10% of students overall. Most students do find that they need assistance in crossing borders into new micro-cultures. Some students who can make the conceptual crossing are labeled "I Don't Know Students."

Named so because of their usual response to scientific questioning, these students do not want to look unintelligent in front of their peers and will look for ways to appropriate information. They usually want to do well but lack the academic skills that may help them make conceptual jumps necessary to cross borders individually.

Another group of students are the “Other Smart Kids,” who can bridge the gap through border crossing, but do not find science endeavors meaningful in their personal lives. Finally, there are the “Outsiders,” who cannot make the conceptual border crossing and ultimately drop out of the learning environment. Later, Aikenhead (2001) discusses how Costa added a fifth category, “Inside Outsider”. These students have difficulty crossing borders to school as a whole due to the culture of friends and family being too different from that of school but are fairly compatible with the culture of science.

The importance of the philosophical stance of Aikenhead’s and Costa’s work is that it encompasses both psychological and sociological constructivist perspectives on learning, rather than negating them. For example, Costa’s work is based on the psychological models of informal learning by anthropologists Alsop and Watts (1997), as well as their work on informal learning in museum settings. There are four components to their learning model. The first component deals with the cognitive. The second addresses the degree to which students can use the information in their everyday life. The third speaks to how the learning is personally relevant, while the fourth component deals with self-esteem that, if not present, can make learning precarious and thus create hazardous border crossings.

As social beings, we border cross from one micro-culture to another every day, most of the time so seamlessly that we are not even aware that we are negotiating the conceptual framework of our thoughts to match our new context. In order to help students border cross effectively, Aikenhead and Jedgede use work by Lugones (1987) which states that flexibility in environment can put both the outsider and the privileged insider at ease. Lugones emphasizes the importance of identity switching or acting differently in different cultures.

Aikenhead (1999) also discusses how enculturation can occur in the science classroom. “Potential Scientists” make a smooth border crossing from their life experiences and the new micro-culture of the science classroom. “Others Students,” he states, play assimilation games, which he refers to as “Fatima’s rules.” In these games, passive assimilation takes place as students simply follow rules or function in such a way as to memorize information but not engage in a meaningful educational experience. “Other Smart Kids” play these assimilation games cleverly, storing scientific information in mental schema until needed and make smooth border crossings. “I Don’t Know” students use these assimilation games consciously. “Outsiders” find it impossible to make a border crossing without upsetting their pre-constructed view of life. Throughout this research, Aikenhead and Jedgede (1999) emphasize the importance of making explicit border crossing in the science classroom in order to reduce the marginalization of students.

Because the enculturation of “Potential Scientists” happens more smoothly in western versus nonwestern cultures, Aikenhead discusses how collateral learning might be used as a possible explanation for the phenomenon. Non-Western scientists, unfamiliar with the traditions or beliefs of the western community of science, will construct multiple cognitive schemas simultaneously. There are three types of schema addressed. There is parallel collateral learning, where conflicting schema do not interact at all, and where compartmentalizations usually take place. Another is secured collateral learning, found at the other end of the collateral learning spectrum. Here, conflicting schema interact. In the middle of this spectrum is dependent collateral learning, where the stronger of the conflicting schema will cause a student to make changes in the other schema without making huge change in the student's overall worldview.

Soft determinism. Just as research tells us that the act of doing science is socially-constructed, and border crossing can help students from different worldviews scaffold new information, technology can also be seen from a community-based perspective as being socially-constructed as well (Mackenzie & Wacjum, 2000; Pinch and Bijker, 1987). Assuming a "soft determinist's view of technology" (Mackenzie and Wajcum, 2000, p. 4), socio-scientific educators view artifacts as having a dualistic nature. Artifacts are tools that not only shape the users by helping diverse learners to border cross successfully by interpreting scientific data in multiple ways; artifacts also are tools that are shaped by the users, as when the tool is situated within a community. Science, Technology and Society (STS) literature is rich with research that discusses how students from various conceptual abilities and socio-cultural backgrounds can benefit from STS issues included in science curriculum (Songer, Lee & Kam, 2002; Tsai, 2001; Pedretti, 1999; McGinn & Roth, 1999; Roth 1995, 1997; Aikenhead, 1994a). Tsai (2001) suggests that STS instruction helps students develop an understanding of the complexities of socio-scientific issues: "STS instruction addresses the active interplay among scientists, technology and society, hence science does not stem from a vacuum. In this way it may shape a more authentic image of science for students" (p. 24).

It is important to note that a socio-cultural constructivist's view of STS is one that emphasizes "the development of shared knowledge through social interaction" (Windschitl & Andre, 1998, p. 146). As quoted in Pinch and Bijker (1987), Barnes (1982a) describes the practice of both technology and science as connected to each other and to the community by asserting that "they are in fact enmeshed in a symbiotic relationship" (p.166). Mackenzie and Wacjum explain:

> [W]hen STS instruction is used in conjunction with an artifact in an objectivist manner, one not assuming that science and technology are interwoven in a community, the science teacher runs the risk of assuming a more hard deterministic perspective (Mackenzie and Wacjum, 2000, p. 5).

With this perspective, technology can be situated as value-neutral and possess the capitalistic and possibly hegemonic intentions of the scientific worldview. Students with different worldviews will most likely have different trajectories with technology. If these trajectories are markedly different from the stable representation of the technology of the time, then the student may not be able to border cross effectively, even with the aid of the technology.

Adopting a soft determinist view of technology – one that emphasizes the flexibility of an object – the socio-scientific teacher can appreciate that even though the technology is still driven by a specific goal, there are many outside social elements that may affect it. With this new multi-goal view, the teacher makes visible the reciprocal relationship between artifacts and social groups. Social relations are now seen as dependent on technology, as much as "technological production is tied to our social actions" (MacKenzie & Wajcman, 2000, p. 143). Technology, now seen from multiple perspectives, can embrace multiple worldviews, and can include multiple elements as a teaching identity evolves. By adopting a soft view of technological determinism, barriers to the practice of science may be identified as soft determinism rejects a universal worldview that produces such barriers.

Critical theory of technology. Feenburg's (1991) critical theory of technology offers an interesting theoretical tool to examine biotechnology. Based on industrialism, Feenburg suggests that individuals have their own trajectory for technology. For example, the technological evolution of biotechnology may look different in different hands. Feenburg suggests that the different trajectories that arise from different actants that intersect in a particular space (like a science classroom) and the power relations which subside there reveal how technology and society are intertwined and co-constructed.

Feenberg's critical theory of technology also emphasizes the democratization of technology. To Feenberg, democratization of technology embraces full participation of all people in the using of technology. In speaking about what it means to democratize technology, Feenberg states, "The problem is not primarily one of legal rights but of initiative and participation" (1992, p. 7). The more people who participate in the use and subsequently the socialization of the technology, the more democratic the technology becomes in our society. By not allowing certain groups of people to participate in the use of the technology, just as in not allowing certain people to obtain full participation in the scientific practices, network builders may inadvertently produce systems of practice that set up barriers which marginalize members of our society.

Critical theories like Feenburg's strive to shape both technical knowledge and practical knowledge into a more realistic interpretation of how science and technology become conceptualized: "This is not a contest for wealth or administrative power, but a struggle to subvert the technical practices, procedures and designs structuring everyday life" (Feenberg, 1992, p. 7). When teachers do not emphasize multiple worldviews in the science classroom, students do not learn the necessary skills to identify spaces of technical opposition or the means by which to change them.

Actor Network Theory

Actor Network Theory works under three main tenets (Law, 1994). First, rather than thinking of people or technology as bounded entities or objects, people and technology are linked in a series of processes or relationships. These processes are thought of as boundary-less agents called assemblages or collectifs (Law, 1994, p. 497). Secondly, these collectifs or processes relate to each other in a "web of relations" (Nespor, 1998, p.3). As relations and associations form, certain topologies or relational arrangements emerge that hold them in place (Nespor, 1998, p. 3). Finally, the actor network theorist considers the networks that are made from many collectifs acting on each other as the producers of social order. In this way, social organization can be affected by network builders, perhaps like corporate stakeholders.

Callon (1986) discusses how the associations of these networks emerge by outlining a four-step process in assembling collectifs into larger networks. This process allows network builders to stabilize identities of members of the community with shared relationships, a process is called problematization (Callon, 1986, p. 204). Most often problematization occurs when network builders such as institutions, including all relationships emerging from them, develop allowable identities and position themselves as passage points for others. In order for this to work, the members have to be detached from the network that originally defines them so that new, more corporate-inspired identities can be stabilized. For example, if there are corporate or global stakeholders who wish to control how biotechnology is taught in schools, they first must remove any social connections from that scientific practice. Without these social foundations, members of the community will be forced to learn a new definition of biotechnology. This new definition can be one which better suits the needs of a free market economy and therefore support global or corporate stakeholder goals.

Network builders use interessment strategies to stabilize the action of actors. These are network building techniques that help newly corporate inspired identities from falling apart. Since these new identities and relationship can not rely on natural connections, interessment strategies can help reinforce artificial relationships and can take on many different shapes, including physical barriers such as walls, discursive barriers such as classifying observations, and material barriers the ways space, time and things are organized in order to restrict others. In our previous example, stakeholders who are trying to control the definition of biotechnology to one that fits a more global or universal perspective will create boundaries or barriers that will prevent that scientific practice from being connected with social intersections. Such connections would cause community members to think of biotechnology in ways that may not be separate from society and, therefore, would not suit the intentions of global stakeholders. Network builders also will use enrollment strategies to make artificial connections between biotechnology's new definition and those already stable identities that were reconstructed in a similar ways earlier into a system of alliances. An example of this would be all of the other forces within a community that would make that artificial relationship between the person and the stakeholder seem natural.

Finally, these re-assembled identities of actors or, in this case, a definition of biotechnology, become mobile in a sense that they can move from one space to another and remain somewhat intact. These mobile actors can be, as Latour (1987) states, are "first displaced and then reassembled at a certain place at a particular time" (p. 216). This mobilization allows for larger institutions to be able to reconstruct these artificial identities in multiple locations. These enrollments and mobilizations stabilize and are identified by people as institutions or activity systems in relation to how irreversible the newly formed links between two actors or agents are. These linkages that change the connections between actors are called "translations" (Latour, 1994, p. 32).

Once these newly formed links or translations are forged, the reassembled network can permeate through the rest of the community, allowing for each new assemblage, translation, and link to be continuously supported so that any new reconstruction can be mobile in the sense that it can be reconstructed in a different place. Network expansion includes changing the world so that the altered network that is built seems valid. It also distributes resistance to this universal worldview in a way that people or relationships that resist a universal worldview become marginalized, even transparent.

Earlier, this research suggested that positivism and determinism are perspectives that have removed social connections from science. Scientific practices are seen now as reproducible in many spaces. This allows for its commodification and therefore supports a free market economy and the global intentions of stakeholders. Stakeholders may want to reinforce the idea of positivism and determinism when discussing biotechnology because it helps to stabilize a non-social definition that in turn will support this network that now reflects global intentions. With these new relationships or translations, members must adopt, or will in many ways force students to either adopt a universal, corporate worldview of science and biotechnology or lose participation and become marginalized.

Most people do not see activity, as in the production of scientific knowledge as webs of relations or as a series of translations, but usually as discrete entities, whether they be a person or a piece of technology (Nespor, 1998). The actor network theorist would suggest that such activity is perceived this way because it incorporates the relationships between the actor and the technology, making it seem to work within the scheme of classification that network builder's support. Only the intermediaries like people and pieces of technology remain visibly stable, while the newly formed relations between the two become stabilized and invisible. In this way, the activity becomes transparent within a network and is referred to as "black boxed" (Latour, 1994, p. 36). Jones (2000) contends that at the moment "when the network achieves some form of consensus, it appears impervious and seems to extend everywhere" (p. 8). The knowledge and technologies that evolve from these intersections are accepted as common knowledge and go unquestioned by the members of a community. Jones provides specific examples of this acceptance:

> Whether we consider the double helix shape of DNA (Latour, 1987), the gendered form of the bicycle (Bijker, 1995), or the intensity and color of a

> fluorescent light bulb (Bijker, 1992), black boxes are the knowledge and technologies, which we take for granted in everyday life (p. 8).

Gone unquestioned, black boxed technologies such as biotechnology and their practices become invisible. Latour (1994) states that black boxing is the "joint production of actors and artifacts entirely opaque" (p. 36). Practices that become invisible are much less subject to criticism and exploration. Once black boxed, the multifunctionality of the technology is lost. It quickly becomes deterministic and greatly supports the universal worldview of the network builder.

Membership and identities. Bowker and Star (1999) suggest that there is a spectrum of membership that leads from casual to committed. This is usually determined by how objects get naturalized in multiple and conflicting ways. If an object or idea is naturalized in multiple ways, then it can diffuse through many types of practices, which determines a casual membership of those who use it. Such would be the case in community-based education. However, if an object or idea is naturalized in one specific way, and does not diffuse into of a variety of practices, then the object or idea determines a much more constrained or committed membership; this would be the case of a more corporate and global perspective.

For this research, the researcher will examine biotechnology as an object or idea that becomes naturalized in the community. If it becomes naturalized in one specific way, either linguistically or philosophically, or it is controlled solely by a stakeholder completely intact and has no other value, then it constrains who defines biotechnology, who can use it, and who can learn it. However, if biotechnology becomes naturalized in a host of ways – both politically, economically, socially, and ethically – then it becomes much more open for all members of the community to use, and membership becomes much more flexible.

Stable identities are easier for the public to understand and for stakeholders to attempt to control because much of the diversity that would make an individual's membership a naturalized object or idea would then be erased. Such stable identities are ways in which network builders attempt to control forms of capital; that is, by categorizing certain thoughts, ideas or people in ways that would make the builders' intentions emerge as the "right" intention or the only intention.

Connections to Research Questions

It is always problematic to set up theoretical underpinnings for a study by developing two different, contrasting philosophies and forcing participants' actions and thoughts to fall neatly under one category. More often than not, the researcher can lose the complexities of participant uniqueness, including the multiple identities that exist within each of us. In contrast to these rather static definitions of corporate and communal, the researcher may find that most people – and especially the participants in the study – quickly become multiple hybrids as they think and reflect on biotechnology within their curriculum. Their thoughts and ideas may illustrate clearly that teachers quickly develop border epistemologies as they use their background knowledge and experiences with newer scientific endeavors to conceptualize biotechnology. In this study, the researcher will investigate how do teachers situate themselves – in the corporate world, communal world, or hybrid version with multiple identities, as Carter (2005) might suggest.

These interpretations of corporate and communal science are even more problematic when one considers biotechnology practices. Kreuzer and Massey (1996) describe biotechnology as using biology to solve problems or produce products. In this very corporate world in which we live, solving problems or producing a product integrally supports a free market economy and therefore would seemingly place biotechnology practices squarely in the corporate camp. However, the intersection of people and biotechnology often consistently reveals the social aspects or ethics involved with science as a human endeavor; thus, biotechnology practices could merge into the communal camp.

Carter (2005) suggests that globalization is not receiving enough attention by the science education community. She suggests that globalization is "underacknowledged and undertheorized" (p. 561), and by examining the relationship between globalization and science education, some of the current forces that impact classrooms may be discerned. Such scrutiny and self-examination can also aid science educators in raising new questions and developing new theoretical constructs. The relationship between biotechnology and globalization seems an interesting beginning for this researcher. It is a type of scientific practice that is not only being taught in some secondary classrooms, but it is also a scientific practice that is currently being defined within a corporate/laboratory world. Therefore, as scientists and teachers practice biotechnology, they develop relationships with stakeholders and others in the community. The researcher is interested in examining what types of relationships emerge and how these relationships develop within a community. Do teachers conceptualize biotechnology within a community based or globally-based construct? And as teachers conceptualize biotechnology within a given construct, how do these relationships emerge?

Chapter Two – Methodology

Introduction

Looking back at the literature review, the researcher developed specific questions concerning the role of stakeholders in the development of biotechnology in the state. He was interested in determining how these roles and perceptions, which connected to the classrooms of teachers who use materials and resources, connected with such stakeholders. He was also intrigued by what differences might be revealed if such a network of intersections could be deconstructed in a community or classroom where science education takes on a more communal feel from that of a classroom where it is seen as more corporate in nature.

A dichotomy between corporate and communal science education was constructed in the literature review which suggested that corporate science education is one where science is seen as value neutral and void of any explicit social or ethical connections. Corporate science education views technology as deterministic, and scientific practices are reassembled in ways that make them reproducible and therefore supportive of a free market economy. On the other end of the spectrum, communal science education sees science as socially constructed, while technology is viewed with much softer determinism. In communal science education, scientific practices are seen as having a stronger connection with the scientists who actually begin the production of science in the community. It is also seen as having more shared interest points from which members of the community can border cross more successfully, therefore eliciting fuller participation.

The beginning of the literature review stated that such a complete dichotomy does not exist. Pragmatically, members see science both as being socially constructed as well as still holding onto certain aspects of positivism. This post-positivistic view of science education emphasizes explicit social and ethical connections with science concepts being taught, while still making connections with elements like that of peer review. Critical theories of technology suggest that members of the community still hold onto some elements of determinism and instrumentalism when speaking of using technology, but also appreciate how flexible the technology becomes as it connects with users. Socio-economic theories featuring upwardly striving students suggest that teachers use their own economic histories to determine connections with students. Along with this, Actor Network Theory suggests that not only networks can be constructed by stakeholders in the community, but also that such networks can be very fragile and sometimes do not completely reconstruct in every community as the stakeholder had planned.

What quickly develops are complex issues that all intersect in how teachers conceptualize biotechnology. Using the literature review as a precipitant for examining such networks, the researcher developed the following research questions that will drive the focus of the study.

Research Questions

The first research question guiding this study is (1) How did the biotechnology education network develop in the state*?* Sub-questions that support this broad question ask what industrial, political or cultural image of biotechnology became defined as members of both the scientific and educational community came together to begin a comprehensive biotechnology education outreach program? Another topic that may provide insight is making more visible how the biotechnology network emerged in relation to the researcher's own experiences with the resources.

The second research question guiding this study is (2) How do biotechnology resources and connections with these resources affect classroom teaching practices? As discussed earlier, teachers develop a teaching identity through the relationships that emerge through being part of a social network. Although the actual view of biotechnology that some teachers use is a powerful tool in stabilizing the definition of objects, membership in a community of practice is an equally powerful tool and one that is used to stabilize identities. These stabilized identities will, in turn, determine enrollment of teachers' participation in biotechnology; this consequently determines the participation of students in teachers' classrooms.

By creating an inviting atmosphere in which teachers can become more familiar with technical equipment, teachers and scientists at the biotechnology center create a community. This community, like any other community, contains boundaries, enrollment strategies and other practices that stabilize it. By exploring how these community practices affect teacher identity, practices that ultimately affect biotechnology curriculum and pedagogy become visible.

The final research question is (3) How do perceived forces within the community such as economic or public perception affect teacher conceptualization of biotechnology? Because biotechnology is a new type of science that in many ways is connected to both economic and political forces within the community, it stands to reason that these forces will in some way shape how teachers conceptualize it. Within this question, the researcher looked specifically for socio-economic differences of students and teachers, as well as determining if or how any conflict between these results in less than full participation by the students in classroom activities regarding biotechnology. Teachers representing both rural and private schools were interviewed at the conference and in their school environment. Of interest was were the intersections that included both the economic and political aspects of biotechnology in the lab and how it is socially situated within their communities. During the course of this research, the researcher was interested in evaluating the significance of forces outside the mainstream science classroom, particularly those affecting the disenfranchised in school communities where biotechnology resources were not readily available. The researcher was also eager to examine the processes of those students who had ample resources, since Brantlinger suggests that science education researchers have begun to examine how teaching practices emerge within more socio-economically affluent environments. Finally, the researcher was curious to see if there were any connections between availability of resources and conceptualization of biotechnology by teachers.

Rationale for Research

The goal of this research is to make visible the network of social relations between the forces that shape biotechnology curricula in rural public schools as well as private schools in the state. Making these connections visible will hopefully help teachers and curriculum specialists reflect more deeply about how these forces that shape biotechnology resources affect the access of biotechnology knowledge, ensuring the fullest participation by all students.

We, as educators, live in a prescriptive age of teaching. We transverse educational landscapes rich with economic, political, technical and cultural perspectives.

Although the community may think that there is one type of teaching practice or one way to teach a particular concept that will somehow magically reach all students, making their lives full and happy, as an educator, the researcher realizes that way of thinking is a fallacy. Classrooms have a rich variety of community memberships in much the same way that the center does. They include the intentions of scientists, teenagers, biotechnologists, consumers, and politicians simultaneously. To believe that one way of teaching or assessing can determine the worth of a student or teacher seems superficial at best and is not supported by either the current science educational research or the National Science Standards (National Research Council, 1996).

Memberships with these micro-communities shape a great deal of how teachers conceptualize biotechnology. For example, a type of membership that may makes a scientist or teacher more committed at work may be offset by several casual community memberships in their home lives. During this research process, it was not uncommon to find scientists or teachers thinking about science in a very positivistic way while simultaneously listening to National Public Radio or talking about biotechnology in a very egalitarian manner. The human race's rich diversity arises from the multiple identities that we construct and the borderland between ideas and thoughts that our bodies and practices interpret. It is the reconstruction of ideas and redefining of definitions according to how we are shaped by these forces within our community that makes biotechnology, or any type of science for that matter, more fluid.

Many interpretations of our lives develop from the categorizations that result from our community ties. Who we are as groups of people, scientists, teachers, consumers, African-American, white, higher or lower socio-economic, becomes static in a sense.

This makes it easy for researchers to categorize both stakeholders and teachers in ways that probably are inaccurate. Casually suggesting that stakeholders or science teachers think in the same way proposes that they have identical community memberships, which they do not.

By its very nature, biotechnology is a type of science that sets itself firmly in the realm of product development. There is no escaping the fact that our society, for better and worse, is inextricably linked to the corporate and political nature of our communities. Because of this, people and practices are summarily categorized, which obviously places certain people in power and marginalizes others.

Research Study Outline

The researcher conducted interviews and made observations of the practices at the biotechnology center that sustain the materials and resources utilized by teachers (see Appendix A). Such practices included interviews with a biotechnology center's lab manager, education director, as well as observations and interviews with participants during and educational conference. A complete chart of the events of the study is included in this section (see Appendix B).

The researcher then began conducting interviews (see Appendix C) at the Biotechnology Center's 2004 educational conference where initial interviews, observations and field-notes were taken. Then, as the resources were checked out on an assigned two-week loan period, the researcher observed the classroom activities and practices of teachers and students as they used the materials from the kit and incorporated them into the biology curriculum. A series of interviews of the classroom teacher were conducted, which included a pre-resources interview discussing the teacher's history with the biotechnology center, and how these teachers see the importance of biotechnology in their curriculum. In this interview, there were also questions concerning the type of students that are enrolled in each class and general information about the community in which the school is located.

A second interview was conducted in order to ascertain how the teacher may have changed lessons to best fit the classroom as the kits arrived at the school. Finally, a third interview was conducted post-instruction with teachers in order to determine how the resources' identity changed and how that change influenced teaching and learning within the classroom (see Appendix D).

The researcher finally developed a comparative case study involving how the biotechnology center's materials and resources become embedded within biology curricula of both a rural and a private, more corporate, school space. The classrooms observed included biology, and chemistry classes in a (1) rural, public high school and (2) in an affluent, tuition-based private school. The researcher began collecting data prior to a biotechnology lab kit arrival at the school as in the case of the rural high school and the private school through interviews and observations of classroom ecology**.**

Data collection. The following assessment data was collected for analysis:

- Audio-taped interviews (30-60 minutes) with the lab manager, educational director and other biotechnology center personnel were conducted. This information was used to illuminate how the social practices of the biotechnology center support: (1) a flow of perspectives which support biotechnology in different communities; (2) the value for the kits and connections between the center and schools statewide, and (3) how the center defines its role in science education in the state in order to construct this network of communication with teachers. Emerson, Fretz and Shaw (1995) also suggest that in order to see a connection with local actions resembling interactions with social forces, “the researcher might move out to examine these institutions and agents and their conditions of existence” (p. 138). By interviewing scientists and educators at the biotechnology center, the researcher could make a clearer connection between the center and teachers who use its resources and correlate this with classroom practices.

- Audio-taped interviews (10-60 minutes) and session observations of both center sponsored summer regional conference will be conducted. This information was used to help better construct a picture of the social network with teachers with the center.
- Field notes were taken at each event and used to triangulate analysis with interviews and artifact analysis.
- Audio-taped interviews (30-90 minutes each) of teachers (to understand better how they value and use materials from a nearby biotechnology center to support teaching and learning in classrooms) was conducted. This information was used to construct a picture of how biotechnology is used in diverse educational settings. School permission to conduct teacher interviews was obtained prior to the interviewing process. Notes were taken during each interview. Emerson, Frentz and Shaw (1995) state that one way that an ethnographer can link local events to social forces is to “attend foremost to how the people involved talked about and understood their connections with these outside forces” (p. 138). By

audio-taping interviews, the researcher could pay close attention to how participants spoke about their experiences.

- Artifacts directly related to the use of the “biotech kits” or the conference (including lesson plans, teacher-made materials, biotechnology center brochures and protocols, assessments of teacher perspectives and student work associated with the biotech laboratory experience) were collected and analyzed. Also, any curriculum information, including public perception like newspaper articles, press releases, was collected and analyzed. This information was used to make more visible how teaching practices and student learning are affected by the use of biotechnology materials. By triangulating teacher interview and observations with classroom observation and analysis of artifacts produced during or in conjunction with biotechnology resources, a clearer picture of teachers' conceptualization could be achieved.

*Sampling***.** Initial sampling for the study was completed through the pilot study during the 2003 Biotechnology Conference. Out of the teachers who were interviewed, one site and one teacher from an affluent private high school were selected. Before the actual study began during the 2004 biotechnology conference, another site was selected; a rural high school and initially two teachers were selected to participate. The researcher wanted to include the rural high school in the study because this was the first time that the researcher had actually made contact with teachers from a rural setting who were interested enough in including biotechnology in their biology curriculum. The setting, the researcher thought, would be very different since there are very few connections with biotechnology, and the community and would be an interesting candidate for this study.

At no time did the researcher assume that either school or individual participant would add any particular context to the study. The researcher simply made special effort to place each "person or group in the context of the system of relations" (Becker, 1987, p. 134). In this way the researcher could prevent the misinterpretation of traits of participants that carry importance in the study from those which may not. Because the study centered around forces like power and school and community politics that affect how systems of relations are interpreted, it was important for the researcher to pay close attention to distinguishing traits that connect with these systems of relations from those that do not.

Analysis of data. Data collected from this study, whether interviews, artifacts or field notes from observations were transcribed no more than one day after the event for utmost clarity. The researcher completed his own transcriptions and made notes in the margin concerning the ecology of the interview; for example, the participant's hand gestures or facial expressions. Although the interpretation of the researcher is one of many possible interpretations that could be achieved by analysis of the data, it was important for the clarity of the researcher's recall of events to list as many notes along with interviews as possible. Maxwell (1996) cautions researchers not to focus on one teacher or one set of students within a classroom to prevent "internal generalizability" (p. 97). The researcher treated each event in each class in each school separately – writing and analyzing them separately.

Once interviews, field notes, and artifacts had been collected and transcribed, then the researcher began to analyze them. The researcher coded each document with small sticky notes according to the following categories: purple notes coded any passage that may pertain to socio-economic or political intersections or conflicts with students that may either cause full participation or lack of full participation; orange notes coded for any passage that discusses technology or biotech used in what the researcher would suggest is a positivistic or deterministic manner; yellow notes coded any personal or professional connection that participants might have with the biotechnology center; blue notes coded passages that include pertinent information concerning the public's perception when biotechnology is used in the classroom; green notes coded any power issues that may arise when biotechnology is used differently in different places. Finally, pink notes coded using biotechnology or technology in general in the classroom in what the researcher would suggest is an egalitarian manner. Once these general categories had been developed, then the researcher went back making connections that became apparent, and developed specific themes for the study.

Validity. In order to prevent the "main threat of valid description" (Maxwell, 1996, p. 89) and attempt to record the most complete interpretation of each event possible, triangulation of data sources was incorporated in the study. Taping and verbatim transcription of interviews, along with observational field-notes and video recording, allowed for multiple means of verifying data and assisting with interpretive accuracy. Participant interpretation, along with the interpretation of the researcher, was not considered the sole, interpretation of an actual event. Throughout the comparative case study, data relating to emerging themes during different stages in the research was compared.

The researcher acknowledged the fact that as a practicing teacher, there would be a familiarity with classroom life and the use of technology that may have inhibited the most complete interpretation of any event. The researcher acknowledges that he assumed many different roles as this research progressed. Teachers and students most likely saw the researcher as a biotechnology education specialist of some type, and therefore treated the researcher in a manner that differed from that of the classroom teacher. Members of the biotechnology center's community most likely saw the researcher as more of an educator, and not as a scientist. This again morphed the role of researcher. Both perspectives prohibited interpretation of events in each domain. The researcher assumed that his role will change from micro-climate to micro-climate. This changing role allowed the researcher to explore the more subtle pedagogical experiences within the classroom, while simultaneously moving to the center's space to examine how practices there affect classroom teaching.

Guiding this case study were the elements of critical ethnography (Barton, 2001) which emphasize the use of research to elevate the living conditions and social justice of all participants. For this reason, all participants had access to information as it emerged within the study and were encouraged to give input at any time. All participants were informed that they might withdraw from the study at any time. Because of any political or scholastic ramifications that may have ensued for students or teachers, the utmost effort to protect all participants was made.

Critical ethnography can be described in this comparative case study as using research to make sense of biotechnology by means of a "critical and political methodological framework in order to aid to the struggle for liberation and in defense of human rights" (Barton, 2001, p. 899). To complete this task, the researcher engaged in research as praxis, considering the “dialectical theory of practice and research shaping that practice in an endless cycle” (Barton, 2001, p. 907).

As stated earlier, as a practicing biology teacher who has used biotechnology kits in the past, the researcher moved into this realm of the research with certain assumptions concerning the political and ethical ramification of using biotechnology within current curriculum. Using critical ethnographic methodology enhanced the ability of the researcher to make the most complete interpretations of events. It also increased the chance that the researcher’s teaching practices could grow along with the research.

As a middle-class white male, the researcher brought certain assumptions into the research that may have also prohibited fullest interpretation. Critical ethnographic methods were also helpful in framing the research, in that it embeds interpretation as situated in cultural beliefs and values (Barton, 2001, p. 906). This led to the researcher being better able to frame interpretation within individual micro-cultures as interpreted by the researcher’s gender or socio-economic background.

Potential risks and benefits. The risks associated with participation in the research appeared to be minimal, if any. Participants were reflecting and discussing events in the already-established curriculum of these schools. Analysis of these events only strengthened teacher pedagogy, student content and social scientific understanding of biotechnology. There was also a deep interest in placing members of both the schools and a biotechnology center in the best light possible.

The benefits of this research would appear to be significant in terms of the potential contribution this research could make to the understanding of how both corporate education and communal education affect teaching and learning. Center participants, along with scientists at the center, will be able to use this information to make biotechnology knowledge more accessible to diverse students, teachers and schools, and teachers can benefit from the professional development opportunity of reflecting deeply about their classroom practices.

Ensuring privacy for subjects. Although it was not be possible to provide absolute anonymity to the participants since their identities will be known by the researcher, confidentiality was strictly preserved. At no time throughout the research (or in any written products or presentations that follow) were participants identified in the analysis of the project without first obtaining written consent and approval (see Appendix E) as according to AAA ethical guidelines, which states “Despite every effort being made to preserve anonymity, it should be made clear to informants that such anonymity may be compromised unintentionally” (AAA Statements on Ethical Guidelines, retrieved January 1, 2005 from http://www.aaanet.org/committees/ethics/ethics.htm)

The biotechnology center is a unique facility, and any anonymity for the center itself will not be possible. Since the facility cannot be kept anonymous, neither were interviews with either the lab manager or the educational director. Although the researcher assigned a pseudonym or code number in place of the name, anyone reading this research and having some working knowledge of the center may be able to identify these participants. Therefore, this was discussed with all center personnel; both written and verbal permission to use material gained by interviews and observations was obtained before this data was analyzed. Only that material, which presented historical facts on how the biotechnology center emerged and connected with teachers, was investigated or represented in this document.

Researcher's relationship with participants. In conducting this study, the researcher was aware that his presence undoubtedly affected the research in some way and the "reflexivity" (Maxwell, 1996, p. 67) impacted the outcomes of interpretation. The researcher was seen as an active participant within the study and not separate or detached from the research. He found that his role shifted and evolved throughout the study

In order to explore more fully how different worldviews intersect biotechnology and how multi-conceptualizations emerge, the researcher examined the micro-culture while in the classroom. Active participation was key in order to investigate what artifacts, knowledge and ideas are of importance to both students and teachers.

The researcher has also borrowed biotechnology equipment from the center previously and continues to do so. The researcher is also an active presenter of workshops at conferences hosted by the biotechnology center. By actively participating in the research experience, a reciprocal exchange of ideas validated the teachers' and students' participation in the study, and strengthened the researcher's views on biotechnology. For this reason feedback was solicited from multiple sources in each research site in order to ensure the most representative interpretation and to prevent bias (Maxwell, 1996). It also allowed for reflection on the researcher's own teaching practices and can help with validation of the study as data collected from the study was made open to interpretation with all participants.

Ethical considerations. Because the study is framed by critical ethnographic methodology, the research participants were equally responsible for generating interpretation of events. For this reason, clear and concise non-technical writing and verbal communication was important for success of the study. In each site, the researcher maintained the highest rapport with all participants. Although the researcher was not only an active participant, but also an observer in the classroom, teachers and students may have perceived this role as having some power and may have felt some reflexivity to the researcher's presence. The researcher studied policies and schedules pertaining to each site for better communication. At any time, if the researcher gained knowledge that would indicate abuse, impending danger or harm in any form, the researcher would have informed authorities even if anonymity of participants is compromised. The researcher will work from the American Anthropological Association ethics guidelines such as relation with those studies, responsibility to the public, and to the science education discipline (AAA Ethical Guidelines, retrieved January 1, 2005 from http://www.aaanet.org/stmts/ethstmnt.htm, 2005).

Chapter Three - Historical Context of the Study

Introduction

There are numerous aspects to the context of this study, including multiple sites where the research was completed, as well as many stakeholders with varying degrees of membership. This complexity necessitates an attempt to construct an historical perspective on the conceptualization of biotechnology education in the state. This also attempts to collect data on the first research question (1) How did the biotechnology education network develop in the state? In order to assist the reader in understanding the temporal sequence of events, and to provide background behind why stakeholders are present and how they carved a niche in this biotechnology landscape, the context of this study will be divided into three main sections.

In the first section, the researcher will lay out an historical perspective of biotechnology education statewide. This section will highlight the teachers and stakeholders who played – and continue to play – an important role in shaping biotechnology education, and how also teachers conceptualize biotechnology. This will help in laying the foundation for the second section of the context of the study; a historical perspective of the biotechnology center. By presenting a deeper understanding of how the different cultures – economic, political and cultural – shape the biotechnology center, the reader will begin to see the multiple roles which community members played in its development. The reader may also begin to develop a clearer understanding of the events that occurred which established current teacher perceptions and understanding of biotechnology, and better illustrate some of the events – corporate political, cultural or otherwise, that influence teacher biotechnology practices. Then the researcher will briefly describe the biotechnology kits and resources that are constructed and maintained at the biotechnology center for teacher use, including the conferences and workshops where participants were selected and also how they became involved in biotechnology education. Lastly, the next section will include the researcher's personal perspective in the growth and development of the field of biotechnology. Being an active researcher/participant in this study, the researcher appreciates that his own teaching history and science practices have been shaped by connections with the biotechnology community. Understanding that the researcher's perceptions of outcomes and his analysis of this study constitutes only one of many possible interpretations, a brief personal history of his intersection with biotechnology education may create a richer understanding for interpretations and reconstruction of events in the study.

To suggest that the biotechnology center arose simply as an entity of a corporate or political existence without any knowledge or relations with community members would suggest that the biotechnology center emerged as a static entity. This is not the case, and herein lies problematic analysis of many corporate institutions. Disenfranchised consumers and those marginalized by corporate or political intent would prefer to identify the public stakeholders as being static controllers with black boxed practices. Of course, this is not an accurate analysis of any corporate stakeholder if we look at current educational and ethnographic research such as Jones (2000). If we, as science education researchers, agree with the philosophies of co-constructed communities and negotiated memberships for other educational institutions such as laboratories, then we must also look at other institutions with different ties to the corporate, political, and cultural infrastructure in the same way.

The Emergence of Biotechnology Education in the State

The educational landscape does not remain static, but changes as forces affect it. This is to say, curriculum will change according to forces outside the community. Those forces can be economic, political, technical or cultural in nature. Most curriculum changes in biotechnology can be traced back to a dominant force or forces from outside the science educational arena that have exerted some pressure on it, in some way making that change. In the case of biotechnology development statewide, it was the College Board and the Advanced Placement Curriculum. Here, the researcher will introduce two of the participants in the study who, throughout their years of teaching, have had a profound effect on how biotechnology education is shaped in the state. The first participant of the study who has had a profound effect on the shaping of biotechnology education in the state is Margaret. Margaret has taught biology at a relatively affluent public high school in the southwestern part of the state for fifteen plus years. She holds a doctorate in science education, and as we will read, has also assumed many leadership positions both local and statewide with the biotechnology center and other science and biotechnology institutions.

Teachers were becoming aware of biotechnology in the late 1980s. It began as an innovative scientific lab that had begun in universities and science labs in the late 1970s. In the late 1980s, Margaret and perhaps just a few other high school science teachers in the state became familiar with biotechnology. These teachers had much in common with one another. First, they each had an interest in the newly-emerging field. It appears that several of these teachers were working as adjunct professors in the community college system and had extended membership with colleges and universities. They noticed that biotechnology was being introduced into college textbooks and lab manuals. Margaret discussed her interest in the very beginning of the biotechnology movement in the state:

> Well, I think it was and is still having impact on all different fields – medicine, agriculture, anything you look at, evolutionary studies, plant biotechnology – It is impacting so many areas and I knew I had followed it from the beginning, when I first started teaching I followed [biotechnology], all the things that were happening and I kept abreast, because I thought it was one of the most exciting areas of biology. I always tried to incorporate it into my own classroom, and I knew it was cutting edge and that teachers needed to be doing this. I was always on top of it, because I taught high school and college, and so I knew the colleges were requiring it and putting it into textbooks and yet it seemed that biology teachers in high school were not with it and I felt that they should be. They should update themselves and keep up with all these things, for their own sakes and the sakes of their students. So that is why I got involved in that, I wanted to keep myself updated, but I also thought it was a good thing for other teachers too. At that time, I was department chairman at Sandstone High School, and I looked around and my other teachers were wanting to know this information too. We need to do it for ourselves (Margaret, 2004, Interview 1, p. 1).

Those schools in the state who had adopted an Advanced Placement Curriculum in Biology developed by the College Board were left with few resources, both economically and professionally, for there was very little training occurring in the state. Unlike neighboring states, the state had no biotechnology centers or corporations from which to generate connections. The teachers who were most interested in biotechnology resources were most likely teachers from different school systems who were teaching Advanced Placement Biology classes. They were also state-wide leaders in science teaching organizations. And although these were not the most dominant forces that would drive biotechnology curriculum during this time, these organizations gave these teachers a line of communication with peers acquainting themselves with biotechnology such as DNA and protein electrophoresis as well as connections with scientists in laboratories.

This exciting and innovative form of science began to emerge through a more powerful stakeholder – teachers' affiliation with the College Board and the Advanced Placement Biology curriculum. Even though these teachers were educational leaders in their perspective schools and belonged to many educational organizations such as the National Biology Teachers' Association, and the National Science Teachers' Association, it was the College Board and not science teachers connections with the university or community college settings which first influenced their thoughts and practice towards biotechnology.

Bridget is a teacher from Granite High School, an affluent private high school – one of the sites included in this research. She has taught biology for over 25 years and has served on many state and local level science consortiums and committees including many College Board and biotechnology center committees. In her professional career, she has taught biotechnology workshops for both the College Board and the biotechnology center. She states, "Unfortunately in order to move your curriculum, you have to have some outside force to make it happen, like the College Board" (Bridget, Interview 2, p. 5). The College Board, more so than any other force, seemed to push biotechnology into the secondary classroom. She got involved with the Advanced Biology Placement curriculum when she began to teach in a private school. Bridget and Margaret were invited to an Advanced Placement Biology Reading, an event where very select teachers were invited to meet at a state university in order to develop Advanced Placement Biology curricula that could be sent out to any school interested in developing an AP Biology class. Bridget described the reading as the first sign that this force was shaping biotechnology at this time in the state. She stated:

> At the reading, there were a lot of very gifted people who were talking about the need for labs, and the "how do we teach" process, is this really biology, The people I am talking about are a professor at Clemson, a professor at the University of Georgia, a professor at the University of Virginia, and a College Board professor, and I think they got a grant. But whatever they did, they wrote out the first six labs, and the College Board made the commitment that they would ask a lab- oriented question based on those labs on every exam. I would have loved to have been a fly on the wall at [the decision making process for] those labs. You think of what is a very pivotal point for so many people and what a wave it has made (or a ripple) it has made in everybody's curriculum (Bridget and Clarisse, 2005, Interview 2, p. 7).

These would be the labs that AP Biology teachers around the country would use as lessons for their classes.

Over the next several years, some of these teachers were chosen to participate in an Advanced Placement Biology workshop at the University of Virginia for several summers. There they were to develop a series of labs that would be disseminated in the form of labs that teachers around the country would use in their Advanced Placement Biology curriculum. These teachers were selected nationally and worked with a series of Advanced Placement Biology writers from Princeton, NJ.

It was when these second labs emerged from the College Board, including one heavy with biotechnology content, that teachers became disenfranchised. Most teachers on the secondary high school level had never covered these topics within their own biological training in school, since the innovative field of biotechnology was just emerging. Bridget stated:

> And when the second set of labs came in, the one of them was on biotech, that just threw everyone into an advanced twit, because it was an restrictive enzyme digest and transformation and who the heck had done that (Bridget and Clarisse, 2005, Interview 2, p. 7).

At this point, it became apparent that many teachers would need not only equipment, but also re-education in order to learn how to complete these labs. For professional development, Bridget looked to the state university. But she speaks to the original force that drove the curriculum when she discussed the second set of labs:

> So they (the College Board) provided the mandate for doing that. You've got to have the equipment, you got to have the faculty know how, and have to have the time to run those things and being on the exam gave the teachers the leverage they needed to get equipment and to get professional

> development and time for the labs (Bridget and Clarisse, 2005, Interview 2, p 7).

Teachers in the state, however were still left with very few resources at the time. Margaret stated:

> I always tried to incorporate [biotechnology] into my own classroom and I knew it was cutting edge and that teachers needed to be doing this. So I kept taking workshops myself to keep updated. And yeah, I would have to go out of state. I would apply for National Science Foundation grants to go do that. At that time there was money available, so I went to Rochester Medical School one summer and took genetic engineering and applied for another grant to go out to Kansas City Medical School for two summers on the Human Genome Project. I also applied for workshop to go to take immunology, because I knew that was an up and coming field (Margaret, 2004, Interview 1, p. 1).

However, for these forces to continue to remain dominant in the state, it quickly became apparent that the College Board would have to provide equipment and education to teachers. The College Board certainly could spearhead training, but that soon was taken over by other emerging stakeholders. Bridget stated:

> Once they [the labs] were in and the College Board had asked a question on restriction enzyme digest on the next Advanced Placement Examination, then there were workshops. College Board's were the first ones, Cold Spring Harbor, then the biotechnology center. It was an interesting historical perspective on that, but I really do give College

> Board the credit for driving the curriculum in that direction (Bridget and Clarisse, 2005, Interview 2, p. 7).

These teachers who were chosen to participate in an Advanced Placement workshop at the University of Virginia met with another emerging stakeholder as they helped write a series of new laboratory procedures with Advanced Placement Biology writers from Princeton, NJ. Bridgett explains: "We would do the labs and they would write them. Carolina Biological Supply Company was there and they did the biotechnology labs [electrophoresis labs] for us each time" (Margaret, 2004, Interview 2, p. 1).
As mentioned earlier, there are economic forces that also play a role in teachers' conceptualization of biotechnology which work with teachers directly. In this case, Carolina Biological Supply quickly saw the teachers' need for equipment to complete Advanced Placement Biology labs within the classroom. They marketed their own electrophoresis equipment along with workshops in how to use this equipment. With very few other resources in the area at the time, this company quickly became a resource and stakeholder in the conceptualization of biotechnology by controlling the resource needs of the teachers.

Teachers throughout the state increasingly became aware of biotechnology through the AP Biology curriculum. The College Board made a commitment to ask questions about biotechnology concepts on national tests, and teachers soon scrambled for available workshops to improve domain knowledge and companies for resources. As time passed, it was these economic and political forces such as Advanced Placement testing and accountability issues with student scores on Advanced Placement tests that shaped how biotechnology emerged on a state level.

As resources improved throughout the state, there was university interest in pursuing biotechnological research on an academic level. This, of course, did not emerge without intersecting with teachers who were at the time hungry for materials, resources, and ideas on how to easily improve what were costly, time- and labor-intensive biotechnology labs. In fact, it was the leadership of Margaret's intersection with members of the university that led to an educational initiative that allowed teachers throughout the state to be granted loan access to equipment, workshops, and educational resources directly through the newly emerging biotechnology center.

Emergence of the Biotechnology Center

In 1990, Margaret attended workshops at Rochester Medical School, University of Virginia, Virginia Catholic University, and University of Kansas Medical School on biotechnology (see Appendix F). She also did workshops at nearby school systems on the Human Genome Project and served on the Biotechnology Association Education committee at the Virginia Center for Innovative Technology (see Appendix F). At this time she applied to the University of Virginia for a $1000.00 fellowship to take a protein electrophoresis class at a local resort, Mountain Lake and to develop a workshop for teachers in the state of Virginia (see Appendix F). She was granted this fellowship to attend the Rochester Medical School one summer and observe genetic engineering (see Appendixes G and H).

Margaret's influence goes well beyond a simple interest in biotechnology. In 1994, she met Mr. Mann, a neighbor of hers. Mr. Mann was an affluent person within the community, a financially successful engineer who graduated from the university and who had served on numerous boards and committees, including a corporate research board of directors. When Mr. Mann passed away, his estate left a sizable amount of money for the development of a biotechnology center associated with the university. Of course, as a neighbor, Margaret had first-hand knowledge of the timing of these events. She knew when he passed away and also that the estate had left money available for biotechnology research.

At the same time, she also met a professor at the university and the person who spearheaded biotechnology research there. It was about this time that several scientists, including Dr. Aye and Dr. Noe, with a deep interest in biotechnology collected at the university and formed a consortium. From its very conception, the biotechnology center had a deep interest in developing an educational component in its mission statement.

But even before the emergence of the biotechnology center, a local professor, Dr. Aye, was interested in developing an outreach educational program. As he looked around at other educational outreach programs, however, he was unsure where to begin. He wanted a program that would fit the needs of the teachers, not tell them what they needed. He also felt strongly that biotechnology education should not be a program that just targeted the elite high schools in the state. Dr. Noe and Dr. Aye contemplated how to go about designing an outreach program for the newly emerging biotech center. When Margaret heard that Mr. Mann's family was going to bequest a rather large sum of money to the university, and because of her alliance with Dr. Aye concerning the biotechnology center, Margaret called the emerging center and asked what they had for teachers and how she could get involved. The professors were pleased to have her input since they had gone to several school systems and other educational avenues with little success. Margaret had many attributes that the emerging center would find helpful, including the fact that she knew many teachers in the state and, because of her leadership positions, had contact with many of them. Margaret stated:

> I had worked with National Association of Biology Teachers a lot, and I was actually one of a few Biology Teacher Association Directors for 5 years, from 1990-1995. And so every year I would get the applications [for] who the outstanding biology teachers were in the state. So I knew who they were through my National Association of Biology Teachers connections. I knew who they were. So when I tried to start this, I went back and tapped these people – people I knew, as well as people I knew through my work with VAST. I was president of that one year, so I kind of knew who the leaders were. You meet the leaders. They were involved in organizations or [were] out there doing things. And so, I knew who they were Dr. Noe and Dr. Aye talked to me about tapping into those people, so that is what I did. (Margaret Interview 1, 2004, p. 5).

It was also at this time (1994) that Margaret was working as a consultant, going around the country with Dr. Noe to see what other biotechnology companies were doing at the time as far as outreach. She visited the North Carolina Biotechnology Center, which was several years ahead of this state because of the research element and research corporations in the community (see Appendixes I, J, and N). She said, "If you look through their educational program projects you will see a very strong tie to the corporate community" (Margaret Interview 1, 2004, p. 2). When asked what it was that precipitated these ties, she said "well they had a vested interest in educating future workers. There are a lot of ties to corporate research, because of the Research Triangle.

Although still interested in broadening her own knowledge, she edited the Kreuzer and Massey text, *Recombinant DNA and Technology*, one most everyone in the country still uses today. Kreuzer and Massey were working in North Carolina at the time. She said:

> We did not want the emphasis of the Biotechnology Center's educational initiative to be so strongly tied to economics. I am thinking that, primarily because they knew it wouldn't work since there were very few biotechnology research institutions in Virginia at the time. (Margaret Interview 1, 2004, p. 2).

Margaret and Dr. Noe also went to Wisconsin to the Wisconsin Biotechnology Center. (see Appendix K). It was also at this time that Margaret presented a workshop at a statewide conference in the state capitol (see Appendix H) and a NABT conference in St. Louis of that year.

Concurrently, a biotechnology educational committee was formed to tap into these human resources. This was a committee of teachers and college professors that were to discuss how biotechnology was emerging and what part they could play in it educationally (see Appendix L). Although this meeting was filled with enthusiasm, very little happened afterwards. Members of the biotechnology center proceeded with their plan to call their own biotechnology educational committee meeting at a centrally-located community college. After the meeting, Margaret was hired as a consultant over the summer to help coordinate outreach trunks, ordering the equipment and materials necessary for teachers to begin to use what they had learned in the workshops in the classroom. At this point, Margaret came up with a proposal for summer activities for 1994 as an "educational coordinator," including setting up traveling trunks and a video loan program. She also had to coordinate with Fotodyne and Carolina Biological to set up traveling trunks.

Educational Outreach Initiatives were set up in 1995 after the biology center building was completed. In 1996, the biotechnology education committee met in April, probably to plan for conferences (see Appendix M). At the first Biotech Conference in June of 1996, the committee met again. It was the last time they met. The researcher thinks this committee merged into a conference committee because Margaret at this time had to return to teach full time after a year's sabbatical.

The biotechnology center. The Biotechnology Center emerged in 1995 and is a setting for interdisciplinary studies for biotechnology research. The center "brings scientists from different disciplines to solve biology's more complex challenges" (biotechnology center website, http://www.fakecenter.com, retrieved August 2000). The center is located on the campus of a university and houses a 44,000 square foot laboratory facility with twelve research labs and special research facilities, including those that support confocal microscopy, transgenic plant green house, computer laboratory, fermentation, and an indoor plant growth facility. It houses nine resident tenured research faculty, one resident research scientist, one education/outreach faculty, one administrative research faculty, one staff laboratory/teaching support, one staff member for special project support, one office manager and one part-time student computer support person. Although the center is located on the campus of the university, it is not an academic department of the university, and therefore reports to its research division of an *Interdisciplinary Studies Office*.

The biotechnology center has a three-tiered mission statement: research, education and outreach. Each has interesting components in relation to this study. There is a great deal of meaningful scientific research that goes on at the center. The nine resident research faculty are involved in on well-funded research projects. The center also encourages interdisciplinary research and frequently invites professors from other departments to participate in on-going research. The research element is an interesting component to this study because the information on the center's website, states that "the center provides an atmosphere conducive to entrepreneurism and the generation of intellectual property is encouraged." It goes on to state that most faculty members at the center have "generated intellectual property or started successful biotechnology companies or both" (biotechnology center website, retrieved August 2000 from http://www.fakewebcitecenter.com). To appreciate how interesting these statements are, one needs to look again at the development of the center.

In one interview with Margaret (2004, Interview 1, p. 1), she made special note of suggesting that one of the biotechnology centers that she and Dr. Noe visited was the North Carolina Biotechnology Center. Surrounded by the many research facilities in the area, this biotechnology center was several years ahead of many of the newly emerging biotech centers in the nation. Margaret shared the education initiatives of the North Carolina biotechnology center and mentioned to the interviewer to take note of the strong business connections that were apparent. When questioned why she thought they emerged in that manner, Margaret replied that is was the pharmaceutical companies and drug companies that had close ties with the center that allowed a business-like agenda to emerge in the educational initiatives. When asked why she thought such educational initiatives did not emerge in the educational mission of the center, she replied, “probably because there were no research companies in the area” (2004, Interview 1, p. 1).

What do scientists do when they are trying to develop intellectual property in an area where there are no research facilities to foster enthusiasm for biotechnology? Naturally it would make sense that scientists at the center would not only have to develop intellectual property, but also have a marketplace in which to give it meaning. It would make sense that the center would emphasize entrepreneurs. This is one of the best ways that new businesses can create a landscape in which to survive. Now, as more community members learn what biotechnology is and value it as a meaningful type of scientific practice in the community, the need to create a corporate landscape becomes less necessary. However, in the beginning, when the center was emerging, it was essential.

The second element to the center’s mission statement is one of education. The center contains two student teaching labs, a classroom and an auditorium for hosting seminars. The center acts as an intersection for interdisciplinary research. Students who are interested can attend lectures and conduct research at the center, but first must be accepted into an academic department of the university before being admitted. Through its endowment, the center offers summer undergraduate research possibilities and mentors students throughout the year.

The philosophy of the biotechnology center acknowledges that “undergraduate education is greatly enhanced when students are immersed in a real research environment working elbow to elbow with research scientists” (biotechnology center website, retrieved August 2000 from http://www.fakewebcitecenter.com). This is an important component of the center's life. At the time of the center's emergence, there was no way to draw students to study this field of science from the more formal academic settings of science departments at the university. Working on realistic science research (with the motivation and emphasis of more socially constructed practices of science, such as social lab practices) sparks genuine enthusiasm, especially when the practice is opened up to the community through corporate ties as well as formal, scientific conceptual ones.

This also helps the center as it emphasizes its relevance by providing a space for students to participate in this type of research. There is a reciprocal influence to this design. By providing a place where undergraduates will want to come to do research, the center presents itself as a unique place for biotechnology research; this place that may not exist in a more traditional undergraduate setting. In doing so, it creates a space for scientists to do research immersed in "realistic science research" (biotechnology center website, retrieved August 2000 from http://www.fakewebcitecenter.com), that is, research existing outside a formal collegiate setting. It also creates an appearance that its existence is necessary for the community of scientists; therefore, a newly forming landscape is created and provides a reason for existing. Without those scientists and undergraduates who participate in interdisciplinary research at the center, no center would exist.

Resources from the biotechnology center. State teachers utilize a program supported by the biotechnology center called "Biotech in a Box". Teachers who have no training in electrophoresis laboratories and those who have extensive experience attend a full day workshop provided by experts at the center. During these workshops, teachers are shown what type of equipment they can use and how to run a simple DNA or protein electrophoresis laboratory in their classrooms. After completing the workshop, teachers are free to sign up to receive all the materials and equipment necessary to run several classes of students through these labs that are packaged in kits.

During their assigned two-week loan period, teachers receive the biotech kits via Federal Express. Kits also have instructions and prepaid materials for the return of these kits after the two-week period, again through Federal Express. Each kit contains up to 10 electrophoresis lab sets, all with perishable materials, including DNA; videos on how to work the equipment and run the labs; and protocols, similar to the ones that the teacher followed during the full day training; and a copy of *DNA Science: A First Course in Recombinant DNA Technology*, by Micklos and Freyer, as well as a copy of *Recombinant DNA and Biotechnology, A Guide for Teachers* by Kreuzer and Massey.

At the end of the two-week period, teachers will clean and repack the kits and send them back to the center. Given the hurried lives of the biology teachers with a hectic schedule, limited space, and even more limited funds, especially ones who live in the standardized ecology of the state's current educational reforms, the center offers these resources throughout the state. Kits travel to all sections of the state, both urban areas in the north as well as rural areas in the southwest.

As a southwestern state teacher who has previously used these kits in the classroom, the researcher became aware that the kits take on a "life of their own" when they are used in a non-laboratory setting. Even though the materials in the kits have their own labeling and, in fact, are enclosed in large plastic boxes with the University Name BioTech labels on them, most of the materials are unpacked and presented in the classroom as most labs are. Because of lab space needs, small boxes – labeled in a way that would keep the technology embedded in an industrial image – are usually placed back in the packing boxes, and the larger boxes that house all the equipment are usually placed in closets or under tables, out of view. Without constant reminders like labeling that would continue to fix the identities of the materials, the kits seem to take on a different connotation, one that is less industrial than the perception the kits have during workshops or when the kits are used with students at the center.

Personal History as It Relates to the Context of the Study

This personal historical context describes how the researcher first began his involvement with biotechnology, and subsequently reflected on the conceptualization of biotechnology, and ultimately the process research questions. The beginning of this research emerged previous to the researcher's pursuit of a graduate degree, when the researcher was actively teaching biology in a public high school.

The researcher's introduction to biotechnology was an abrupt one. In his second year of teaching, he was asked by the principal of his school to teach an Advanced Placement Biology class. As a novice to the curriculum, the researcher soon realized that this would mean he would have to learn to teach the concepts and protocols of electrophoresis, as these are laboratories mandated by the Advanced Placement Biology curriculum. Not having had any formal training in this lab procedure in his undergraduate program, the researcher attended an Advanced Placement conference where he met with a colleague, Margaret, who taught Advanced Placement Biology in a neighboring county. Margaret advised him to attend workshops that the biotechnology center offered. This would not only give him a "crash course" in the lab procedures and concepts associated with electrophoresis, but would also allow him to obtain, at no cost, expensive equipment and supplies of DNA and enzymes necessary to complete the labs.

The researcher went through the training of the workshops and scheduled the equipment to be delivered to his school in December of that teaching year. When December came, he was excited as 4 huge boxes were delivered to his school. Included in the boxes were the materials necessary to run 30 students through an electrophoresis laboratory. Also included were books, videotapes and even a lab coat with the words University Name Biotech silk-screened on the pocket. The researcher and his students followed the protocols to the letter. For the most part, his students were able to perform an in-class DNA digest and were able to obtain a gel where different size DNA strands could easily be seen and identified.

As his experience and subsequently interest in the lab proceeded, the researcher found that his affiliation with the biotechnology center grew stronger. He became more interested in the scientific concepts behind the lab and found himself becoming enculturated in the microculture of the center. As the researcher's domain-specific knowledge grew, he took a rather traditional scientific approach to teaching electrophoresis in his classroom, stressing mostly the scientific concepts involved. He attended conferences and enrolled in a graduate level genetics course, then served as a national conference committee member for the center for several years. The culmination of this period of his teaching ended in assisting professors at the center with a graduate training course in recombinant DNA technology and bacterial cloning. He found it strange that a secondary school teacher with little graduate level training was embraced so readily by a center filled with biotech experience much more advanced than his. This environment felt in some ways familial, much like the feelings fellow teachers share within a school.

After several years the researcher felt comfortable with the specific concepts and procedures that electrophoresis includes. He attended workshops and conferences less frequently and borrowed equipment only when he planned to teach electrophoresis labs in his classroom. It was at this time that the researcher entered his doctoral studies at a local university. In the formal classes, the researcher was exposed to theories of constructivism and other socially rich theories of education. The researcher was also serving as the science education graduate teaching assistant, working with student teachers and having the opportunity to explore the conceptualizations of scientific knowledge in different counties and educational settings.

One of the student teachers in this group was a former science student at the researcher's home school. The first assignment of the fall semester was for this student to construct a visual road map of how he got to this point in his life. He specifically mentioned his valuable experience from the researcher's high school classroom. For all we know, the student may have made this comment thinking it would make his student teaching experience easier if he could gain the researcher's favor. However, full of pride that a student of the researcher's would want to explore science teaching as a profession, he entered an analysis of educational concepts class. The professor inquired about the researcher's good mood and the he explained the good experience with the student teacher. The professor stated:

> Well, are you surprised that this student heard your voice in class? You and he share the same race, gender, socio-economic and geographical

> background. How many young women or students of color, or students from different socio-economic backgrounds have you had a similar experience with? (McLaughlin, Personal Journal, 2000, p. 1)

It was then that the researcher began to take note of the emerging body of research in science education, which stressed the implicit instruction of socio-scientific issues and the field's connections to capitalism within curriculum. The researcher was now eager to add elements of critical pedagogy, cultural boarder crossing, and network tracing ideology into his science curriculum.

Current educational standards required that the researcher continue to include technical knowledge such a molecular biology and its relation to larger living systems into the biotechnology curriculum. In many ways, these standards also dictated how the researcher would teach these concepts. Because of the limited amount of time and the breadth of material necessary to cover, direct instruction was and still is the teaching model of choice by many science teachers, and (shamefully) the researcher's.

Unlike other teachers at his school, the researcher continued to borrow the equipment from the center and had students run through the labs. However, now the researcher was emphasizing social heterogeneity of the technology at the same time he was including technical knowledge. Even though the researcher was appropriating the knowledge, he found that his classroom awareness and teaching practices were transforming. It was and still is an extremely uncomfortable experience.

In the past the researcher found himself teaching both DNA and protein electrophoresis in a relatively positivistic manner, emphasizing technical knowledge. Personal teaching practices were based solely on following protocols, producing electrophoresis gels and analyzing results. Personal pedagogies paid very little attention to how value-laden the laboratory practices of electrophoresis are or how these values affect society. For example, there was little planning or implementing lessons that might address how the biotechnology center decides what types of knowledge are considered relevant, and what types are not, and how they are supported and transferred in a standardized educational environment. Since technical knowledge was most of what was presented to him, either in the form of workshops, materials or protocols, only presented technical knowledge emerged in the classroom.

The researcher found himself, along with students, wanting to use the lab experience as a springboard for discussions on bioethics, the nature of science, and how these issues relate to our capitalistic society and mobility within communities. It seemed that after domain-specific knowledge and the diversification of personal teaching practices was obtained, the researcher was able to use the materials in a somewhat different way than was originally conceived by either the biotechnology center or the Advanced Placement curriculum. However, neither the biotechnology center nor his colleagues provided much support for these new teaching practices.

The researcher's students followed protocols that emphasized technical knowledge and presented technology as unchanged by those who used it. When he spoke to his students or other teachers, he spoke in a language that was filled with abbreviations of technical knowledge, like "running a gel" that only people who had technical knowledge in biotechnology would understand. Very little attention was paid to biotechnology as an intersection that could be used to explore how science is socially constructed or how it emerges within society.

The Public's Perception of Biotechnology

Ironically, as biotechnology was becoming less socially constructed in the classroom, the field of biotechnology was becoming more prevalent in the public's discourse. The public was becoming fascinated with this new type of science; the way it was and still is being represented makes a big difference in how biotechnology becomes conceptualized.

In places where there was no biotechnology industry or research being done, and members of the community were not familiar with the scientific practice, public awareness of biotechnology seems to be limited to television programming and movies. Time and time again the television show, *Crime Scene Investigation* (CSI), was mentioned by scientists, teachers, and members of the public in this research.

Gail was a teacher in the rural public school, one site included in this study. She was a state forensic examiner for several years before she decided on a career change and came to the rural public school to teach biology. Involved in the biotechnology job market when it was first emerging in the state, she remembered when the perception of biotechnology took note of a shift in the level of interest by the public in biotechnology:

> I can tell you exactly when it started. It didn't start with *Quincy* if you are old enough to remember that one. It started with OJ Simpson and nine months of televised forensic testimony, and shoe prints, and Bruno Magli shoes and blood splatter and Dr. Henry Nees standing up there and testifying. That is when it started. I was doing an internship in a crime lab that summer on DNA testimony, so I was already doing it. Now *Court TV* is showing it, *Cops* and *Americas Most Wanted* and they figured out that

> the closer and closer you got to reality tv the more public interest you can entice. Producers started realizing that truth was more interesting than a lot of people could write. There was stuff that happens in crime scenarios that is much more exciting than someone could imagine and focusing television shows on it. *CSI* is the most recent incarnation of that, but it started a little before *CSI; Discovery Channel* and *The Learning Channel* had *Cold Case Files*, where they interviewed scientists and decided to "Hollywood it up" and got a hit show. I don't like *CSI*; I don't watch it because I was in the field, but I do appreciate the dramatization of it. It is a dramatic show and is very suspenseful. When you have got a hit show, you have an audience and that is where people get their perceptions of what it [biotechnology] is (Gail, Interview 1, 2004, p. 2).

Without a direct connection with the science, the public has very little perception of biotechnology other than what they see on television or see in newspapers. In this way, the media has been a driving force that has shaped public perception of biotechnology in the community. At the time of the study, there were no industries or biotechnology corporations in the area, and therefore direct contact with the science through working in a factory or lab was not possible.

During the researcher's visit to Little Rock High School, a local newspaper contacted the rural school, by telephone and interviewed Francis, one of the participants, for an article that would be printed describing this exciting laboratory experience in which the students at the high school were participating. This is not an unusual event, because the biotechnology center sends out press releases to local news media and interested parities, making them aware of the biotechnology loan project in local schools.

The press attention was not only centered at Little Rock, but was also directed towards the researcher himself when the same lab was completed with the researcher's Advanced Placement Biology class. In order to find out why this would interest the media, the researcher interviewed the reporter, a long-time member of the community, to see how biotechnology was perceived by the public. Adrianne has worked for a local newspaper for many years and has many ties within the community. When asked what she saw and what kind of exposure members of the researcher's community had with biotechnology, she stated:

> I think your average member of the population probably knows very little about it. And with the article that we ran, a lot of people said; 'I didn't even know they could study things like that.' That was some of the feedback that we got on it. With the people in the southern end of the county coming from other areas, they may be more aware, but I think your average county member knows very little about biotechnology (Adrianne Interview 1, 2005, p. 1).

When asked why that was, Adrianne suggested that:

> There is not a lot of biotechnology industry around in the area yet. I think that is one thing. Unless they [citizens] are exposed to it on a daily basis, I think that is what it is. You know a local health care facility and places like that are talking about putting in a biotechnology firm. Let a few of them start working there, and

> more people will know about it. It is not familiar to them. They don't know anything about the seafood industry, either. You know what I mean (Adrianne, Interview 1, 2005, p. 2).

If the perception of biotechnology is not moving strictly through the community from the laboratory to the classroom, then one has to ponder the linguistic step it takes in its journey. This perception can take one of two shared linguistic routes. It can either be filtered through business and industry, like biotechnology corporations or research facilities which locate themselves within a certain community, or through the perception of biotechnology can be filtered in the media. In this rural area, it seemed that the public's largest force shaping biotechnology perceptions was the media.

Public's perception of biotechnology as influenced by the media. This leads us to an interesting phenomenon about biotechnology awareness in the community. If a community is not located near a biotechnology facility of some type, research, economic or academic, then most of that public's awareness of biotechnology comes from the media. Adrianne continues:

> Well, I will tell you what has brought some biotechnology to the county – all of these *CSI* and we are back to "entertain me and I will learn." I have only watched *CSI: Miami* one time, but I found it to be simplistic and I thought; 'what kind of idiot watches this?' and went downstairs and saw my husband and my children watching it (Adrianne, Interview 1, 2005, p. 2).

When asked what she meant by simplistic, she described how during an episode of the show she watched, the scientists brought a laser to a crime scene and used it to determine the time of death of a person and thus determined that the person died before the plane he was on crashed. From her work with the county coroner, she said, “The coroner can determine a time of death within a window of 2-4 hours” (Adrianne, Interview 1, 2005, p. 2). Saying “simplistic”, she means that both the human and technological limitations of science are not shown. Therefore, the viewing audience developed a perception of science which is always truthful and always correct, or in essence, positivistic. This technology is also seen as deterministic for the same reasons.

A positivistic and deterministic perception of biotechnology through the media permeated through the entire study. Every person interviewed, whether scientist, educator, reporter, vendor of administrator, mentioned the television series *CSI*. What was interesting was that no participant in this study mentioned *Cold Case Files* or a host of other more realistic shows on cable networks that present both the science and the humanistic perspectives of solving crimes and medical mysteries using biotechnology. Each participant, as well as students in several of the classes that were observed, mentioned *CSI* and its spin-off shows. Adrianne suggested that *CSI* had a simplistic ending. This is not uncommon. By “simplistic” she meant always coming up with a right and a wrong answer. Because of the dramatization of court cases, and the need for an ending, science tends to be portrayed in a much more positivistic manner.

What soon becomes evident is that the public does not have a great deal of access to biotechnology in this part of the state. Therefore, the perception of biotechnology, one that emerges mostly from the media, gives a sense of the science being very positivistic in nature. Within the media, there is always a strong sense of being able to derive a right answer from biotechnology. There is a strong sense of instrumentalism with the technology and although the many of the television shows are dramatizations, it seems that the human endeavor is removed from the science (Mackenzie and Wacjum, 2000; Feenburg, 1991; Johansen, 1991).

Summary

As this story tells us, there were many interested participants from the community that had a vested interest as well as scientific and philosophical interests in having biotechnology become a staple in the high school biology curriculum. First of all were the teachers. These were members of the community with specific memberships in different organizations. They had somewhat strong memberships with the community college and the university setting. These teachers were exposed to biotechnology for the very first time, either in textbooks that they were using, or labs that they were teaching the undergraduates. With their connections to the college science intersection, these teachers began to see that biotechnology was an important field of science that needed to be included on the high school educational level. Fueled by their own interest in this scientific practice, as well as their farsightedness in determining that biotechnology would be a very active element in the field, these teachers quickly set a chain of curriculum events to work. Additionally, the power of authority given such teachers when new scientific elements were brought back to their home high schools and to their peers was enticing. This encouraged these teachers to begin to look for avenues to incorporate biotechnology into the existing curriculum.

These teachers were then placed in a precarious position as the College Board – also acknowledging this emerging science – politically placed it in the foreground by including it in a standardized Advanced Placement Biology curriculum, as well as asking questions about it on Advanced Placement tests. Teachers were looking for content and laboratory resources to help them bring biotechnology into the classroom.

In developing the Advanced Biology curriculum, the College Board members had a vested interest in making biotechnology a part of the secondary Advanced Placement curriculum. Any time new and relatively exciting scientific concepts can be included in the AP curriculum, more confidence builds among the school environment, an environment including administration, parents, community leaders, and the testing service. This certainly would lead to expanding the Advanced Placement curriculum to more schools.

In their search, these teachers connected with other stakeholders, that are somewhat more corporate in nature: those are comprised of biological supply companies, who at the time were active in getting a foothold into designing and marketing biotechnology products for an untapped resource, secondary science teachers.

The very existence of the biotechnology center was predicated on its generating scientific interest in an area where there were few research resources. Unlike other centers at the time that seemed to emphasize a more corporate "making new workers" relationship, the center and the community attempted to construct an entire corporate landscape in which the center could exist. In doing so, it needed strong connections with the community. One of those ties was a close connection with statewide secondary science teachers. As time passed, teachers began to request equal amounts of domain knowledge and more culturally explicit knowledge, which the biotechnology kits now provide.

At the current time, there are many different levels of teachers with varying degrees of experience with biotechnology. They teach in radically different communities with different worldviews and beliefs. They also teach in schools with varying degrees of financial ability to offer science equipment. Consequently, for this study, the researcher chose to explore teachers who are using these kits in their classrooms or who in some way continue to have some affiliation with the biotechnology center.

Chapter Four: The 2004 Biotechnology Center Educational Conference

Introduction

The biotechnology center hosts a four-day educational conference every year. The purpose of this conference is to present new research and teaching ideas to middle and high school teachers as well as college professors. The first day is developed for teachers new to the field of biotechnology, who attend Biotech Boot Camp. During this workshop, teachers are taken through rudimentary biotechnology labs such as DNA electrophoresis and bacterial transformation. The second day is actually the first official day of the conference for all participants and consists of a morning of three research-oriented lectures followed by lunch and an afternoon of laboratory experiences. The lectures are presented by leading scientists in the field of biotechnology, usually recognized nationally. The workshops are held by local experts – scientists at the biotechnology center and by biotech corporations like Carolina Biological Supply, Photodyne, and Bio-Rad. The third day's schedule is identical, with morning lectures and afternoon labs. The last day consists of only lab workshops. During registration, teachers can sign up for the labs they want to attend. Popular workshops are held several times in order to assure participant attendance. There is usually a social mixer of some sort during the evening of the first day and a wrap-up dinner on the last day.

On the night before the first day of the 2004 conference, teachers were invited to attend a one-woman show on the life of Barbara McClintock, Nobel Prize-winning geneticist. After the play, a roundtable of academic community members discussed the importance of McClintock's life and work. The panel consisted of a white female scientific historian, a white male a graduate student, a white male ethicist, a white female molecular chemist, and the actor portraying McClintock. The play and roundtable were held on the university campus.

The full audience really seemed to enjoy the play and its insight. During the roundtable, comments were made by the panel such as "Science is an artistic endeavor; students are inspired by scientists' stories and by your [meaning the science teachers'] stories and that courage and passion are interwoven in scientific research" (Researcher's Journal 2004, p. 2). The reason the researcher included this passage from the one-woman show about Barbara McClintock was to present for the reader a new emphasis on discussing biotechnology issues from multiple perspectives that was emerging through the conference.

The theme of the first day of the conference was new ways of looking at methodology when exploring biotechnology. There were two lectures – one that consisted of looking at the autonomic genetic screening processes that Americans use in comparison to those philosophies of Europe; one showed how we can use genetic screening to trace racial or cultural migrations of people. Throughout both lectures, the theme of using less autonomic ways of thinking about doing science emerged. Whether it was redefining race, ethnicity or human lineage in the second lecture, or the thinking about a less autonomic was of thinking about genetic screening and banking genetic information, as in the first lecture, "out-of-the-box" methodologies was emphasized. The audience left thinking about how adhering to the historically-based, positivistic "physics" model of science might not make biotechnology helpful to people, since the science itself has just now begun to permeate the general public. The public and scientists seem to have adopted a very static view of DNA. What distinguished McClintock is that she saw

DNA as a fluid entity, which allowed her to make her discoveries while not working within the standard research paradigm. The speakers for the first day both led the audience to believe that again we are looking at issues of race and community in a much too static way. When we look at issues of race and biotechnology with an historical or anthropological bias; we see that humans (and therefore their genes) are much more fluid; we need to derive models that are equally capable of researching the fluidity of genomes. One presenter suggested that as Americans, we have a much too static view of community. Within the context of population genetics, we see that we do have much to gain by adopting a communal perspective on how we legislate DNA. The first presenter's talk really seemed to make the audience think about shifting a paradigm of thinking. The second presenter's talk was a bit more user-friendly and the researcher thought that most people in the audience would be interested in rethinking racial issues in the sense of unity and community. Comments such as "we are all one people," "diversity is good," and "it is a much more difficult task to ask people seemingly to give up personal freedoms to really become free" were made by these presenters.

The second presentation was on anthropologic genomics; the presenter started off by thanking teachers for their work and suggested that biotechnology is the integrated science of the 21st century. She continued with the comment, "Scientists don't like to say we have assumptions but we do." She stated that there was more genomic diversity in Africa than outside it; she winked at the audience and said: "We are closer to each other than we would like to admit." Everyone laughed, considering the presenter was an African-American woman. She discussed how ethnogenic layering helped her research team look at regional differences in genomic frequencies in the Chesapeake Bay, Carolina Coast, and Mississippi Delta areas through the interpretation of an ethno-historical framework. She stated that "Fluidity of culture has genomic consequences," which the researcher interpreted as a more generalized ethnicity. She also stated that: "race is social pathology." The audience was enthralled when she said that the Asian female is the most common genotype, but we don't experiment using that model.

The second day of the conference featured a plant presentation. The presenter used many war metaphors, beginning with a *Mad Magazine* images, and also used surveillance metaphors. He discussed the socio-economic impact of plant disease. He reviewed how plants recognize pathogens, how transduction of the recognition signal turns into defense responses, and discussed potential applications of basic research on plant defense.

It was interesting to observe that throughout the educational conference, the multiple ways in which scientists discuss the practice of biotechnology and science in general were emphasized. In a space like a conference, where one-on-one relationships are built between teachers and scientists, a softer view of a deterministic image of biotechnology was certainly achieved.

Analysis of Documents from the Conference

As is the case at almost every educational conference, regardless of subject matter, this conference readily offered a table of pamphlets and resource materials for teachers to take and use in their curriculum and classrooms. These materials ranged from posters of the Human Genome – listed chromosome by chromosome – to materials from the Department of Energy on careers in genetics and bioscience, to free periodicals from biotechnology industries. For purposes of this research, the materials were coded for sponsor and information.

Department of energy. Many of the pamphlets on the resource table were provided by the U.S. Department of Energy. There was a receptionist at this table with a large tri-fold display of genetic posters describing research in the field of genetics and human genome landmarks. Pamphlet 1 was entitled "Careers in Genetic and the Biosciences" and was sponsored by the Human Genome Program of the US Department of Energy Office of Science's Office of Biological and Environmental Research. The document listed possible career opportunities in the field of biotechnology. The document had cartoons of African-American women on the top and in the middle, advertising a tie to minority communities. It stated that the benefits of biotechnology would be felt in many different fields of science including ecology, toxicology, and so forth. Information in the document stated:

> Every effort must be made to ensure that each person –regardless of race, citizenship or national origin – enjoys the benefits of genomic research and its subsequent application, including life improvements and excellent career possibilities (Document 1).

Tying career opportunities to the concept of biotechnology is one way that biotechnology can be commoditized and used to support the corporate end of the practice (Saltman, 2000); to support biotechnology within a capitalistic world, a market must be produced and sustained. The Department of Energy suggests that to enjoy the benefits, one must want the benefits, which creates a desire and/or need for the product. At the same time, stating that there will be “excellent career opportunities” suggests that people should want to enter this workforce.

The wording in this document is somewhat condescending. In one section, about how one should prepare for a career in the biosciences, states: “People need science and technology basics, training in computer use and information technology and education in bioethics to anticipate and present options for solving prickly social issues” (Document 1). Possible genetic and biotechnological costs to humanity could possible be great, certainly complex individually – and describing them as “prickly” would suggest that they are not as complex as they are.

The second document from the Department of Energy is entitled *Exploring Genetic Issues Relevant to Minority Communities* and discusses what the department is doing to meet the challenges that minority communities may have with the human genome project. There is a small dialogue box on the bottom of the front side of this document entitled “Whose Genome Is It Anyway.” This document discusses how several people have donated samples of the DNA in order for the human genome project to have something with which to compare its data. It suggests that 99% of human DNA is identical and it states: “Studies of human variations have determined that there is no scientific basis for race and that races cannot be distinguished genetically.” This is not altogether true. An article appearing in *Scientific American*, “Does Race Exist?” by Bamshed and Olson (2003), states that races do not scientifically exist as we human now tend to categorize them, i.e. black, white, etc. However, there are genetic links between groups of people biogeographically.

For the Department of Energy to suggest this without a disclaimer about how race and our perceptions of race have evolved, leads the reader to believe that minorities exist only through their own marginalization. Similar to the “upward striving” and “already there” teachers in the Brantlinger (2003) study or the border crossing students in Aikenhead and Jedgde (1999) and Costa (1995), the Department of Energy suggests that the world is a common playing field and all humans have the opportunity to succeed if they try hard enough. This type of thinking does two things. It suggests that minorities have not worked hard enough to achieve the same degree of success as those whom we would classify as middle-to-upper socio-economic. This recapitulates a power struggle between those who have tried and succeeded and those who have not. It also supports the use of biotechnology through determinism. Using biotechnology to produce a solution to a biological problem that can be manufactured, advertised as something that humans want, and creating a market for it, supports a free market economy and corporate science. Since this flier was meant for teachers to take and share in the classroom, it now becomes a device to send this strong message of social class and capitalism to students.

The Department of Energy does produce a nice learning tool in the form of a Human Genome Landmarks poster that lists each chromosome with selected traits and disorders located on gene loci. It is accompanied by a small poster that explains how to read it and gives students an excellent way to further their understanding of genetic mapping while piquing their interest as they recognize traits and disorders. It also has an adjoining chart that lists many websites for students and teachers to visit for further scientific information on the Human Genome Project, genetics, and microbiology.

Another Department of Energy product which is an asset to the classroom is its "Cracking the Code of Life" timeline poster. One side has a timeline of events in the development of humans' understanding of the human genome and on the back it features pictorials of basic genetic concepts that students and teachers must comprehend in order to understand how scientists have completed the human genome series.

The Department of Education offers a poster entitled "Microbial Genome Program," which discusses relevant missions of the DOE and about the enormous range of capabilities that microbes possess. The poster is divided into 6 blocks. Each block has a DOE mission, a small explanation of what that mission means, and a list of microbes used in that mission. The missions are Bioremediation, which is now a staple question on the Earth Science SOL exam; energy production and development of renewable energy sources; Cellulose Degradation, the conversion of biomass to products such as ethanol; carbon sequestration, managing the Earth's carbon to maintain a stable environment; Biotechnology and applied microbiology, the production of chemical to improve process efficiency; and Technology Development, Interagency Projects, demonstration and pilot projects. In each of these blocks there are words like "products" and management that denote production, which in turn denote a free market economy. Words like "efficient" and "improve" suggest a need or desire to signify a market for the product (Callahan, 1962).

Another document entitled "Meet the Microbes" is also available. This is a series of lesson plans on microbiology for middle and high school and is presented by the DOE and the Community Initiative of the Microbial Literacy Collaborative. It is very anthropomorphic in the way it presents microbes with facial expressions, but contains some good information in it about basic scientific principles necessary for students to understand before they can make the connection between genetics and microbes.

The DOE also gave out promotional red pens with their name and a picture of the double helix on it. To teachers, office supplies are like gold, so this was a good way to advertise wares in a market that would not usually be connected with the DOE in the first place.

Biotechnology industry organization. The Biotechnology Industry Organization provided a document entitled “Business 2.0”, which introduces bioengineered products ready to hit the market. It continued this close connection with corporate science by suggesting the industrial biotechnology issues may not be a controversial as other biotech issues:

> As it is well known, the mere thought of biotechnology stirs controversy in some quarters. But industrial biotech may not provoke the same angst as has cloning, or even genetically altered corn plants. Bioengineered medicines haven’t drawn much opposition because the benefits to consumers are obvious and the transgenic organisms used to create them aren’t growing in farmer’s fields (Document 2).

Again we see rationalization here for biotechnology because of the benefits to consumers; however, the benefits are not to humans in general, but to those who participate in the free market community. One interesting thought that this passage provokes is the fact that since humans cannot see the bioengineering practice being done, they are removed from it. This removes the human factor from the scientific practices again, making it “black-boxed,” positivistic, and ripe for use in a corporate community.

The biotechnology institute. The Biotechnology Institute is an independent non-profit, national organization dedicated to education and research about the impact of biotechnology. Its mission is “to engage, excite, and educate the public, particularly young people, about biotechnology and the immense potential for solving human health, food and environmental problems” (Document 3). The literature continued by saying that it includes in each issue “issues of health care, agriculture, the environment, and industry” (Document 3). The Biotechnology Institute is based out of the northern part of the state and includes topics as diverse as “How many products are already affected by industrial biotech” to “How can industrial biotechnology protect the environment?” (Document 4). Again, each article makes a strong connection between the scientific concept of biotechnology and the economic marketplace by forging the link between product and consumer.

This document makes connections between how America with the help of industrial biotech can move from a dependence upon Middle Eastern oil to that of the Midwest, which currently appeals to many conservative members of the community. In one article, “Home Sweet Biotech,” there is a small dialogue box that states that humans can be grateful to the biotechnology industry for providing artificial sweeteners adjacent to a picture of a young girl and an article about the biotechnology of making a pair of blue jeans. Although this may be completely innocuous, there could be a connection between the commoditization of body types and clothing to that of dieting.

Speaking about biotechnology with only one voice, one that resonates in a consumer-producer relationship, suggests that the science is positivistic in nature and the technology is only used instrumentally. This isolates the biotechnology practice and allows it to be used to secure social class hierarchies, which ultimately supports theories and practices of domination over marginalized people.

Conference Analysis

Why is this conference analysis important? Obviously, teachers are exposed to economic, political, and humanistic forces that permeate the biotechnology center during the conference. Although many of the documents were more corporate or political in nature, the dialogue that occurred within the workshops, presentations and special events (such as the play and panel) suggests that there is a rich cultural expression of ideas as well. It is likely that since this is a conference hosted by and presenting biotechnology, most participants would agree that biotechnology is a practice of science that should be embraced by the population. Analysis of the conference presentations that took place reveals that there are many different perspectives on the nature of science that exist among the conference participants and leaders.

We can see that through analysis of the documents available for participants at the biotechnology center a strong emphasis on how biotechnology can be used in different places in similar ways. This is reminiscent of an objective view of technology (Johansen, 1991), where technology is thought to be unchanging and therefore reproducible. It also becomes apparent through this type of analysis that technology is viewed as being strictly deterministic, because it supports the production of technical knowledge only.

However, this perspective does not reflect the more humanistic epistemologies of the academic community. When interviewing scientists at the biotechnology center on the philosophies of the resources made available to the participants, scientists spoke in a much more egalitarian manner. While discussing the use of the educational resources at the center, the lab manager spoke favorably about different educational communities using the materials as she stated, "Population centers will use it more, but we also have users in the coal country of south west and down in southern part of the state, so it's diverse" (Scientist Bringham, Interview 1, 2005, p. 1). Margaret speaks to this mission as well, noting that there was an effort to make the resources at the biotechnology center malleable enough for all learners to benefit from, not just the economic elite. She and the center attempted not to develop curriculum that was not too closely tied to economic research, as in bordering states.

The researcher finds that scientists at the biotechnology center possess ways of thinking that are hybrid in nature. The ways in which they speak about biotechnology are what the researcher would consider to be socially constructed in nature. This phenomenon is very similar to what the research of Glasson and Bentley (2000) suggests - scientists speak in multiple ways about their laboratory practices; furthermore Roth and Lawless (2002) suggest that laboratory practices are embedded in a culture.

However, in years past, resources have been arranged in ways that emphasized strict determinism. This could have been due to a variety of reasons. Most probably, teachers needed to feel comfortable in domain knowledge before they were able to interpret curriculum through varied perspectives. It might have been to the center's advantage to begin talking and producing educational materials with a more strict sense of instrumentalism. Now that public perception and interest have made biotechnology more familiar, teachers feel more comfortable talking about the concepts behind the laboratory practice, they can now begin to draw upon their common knowledge – the information that they hear about on television may have interested them enough to scaffold new information resulting in stronger domain knowledge. Once domain knowledge is strengthened, teachers may then feel more comfortable talking about even more complex social issues that are associated with biotechnology. At this point, teachers ask for more ethical information, and the center is adding different scenarios for doing labs in class that explicitly illustrate the social ramifications of biotechnical practices in the community. Some of these scenarios include diagnosing certain genetic illnesses, and using data to look at evolutionary relationships.

Just as the researcher and other teachers began to voice concerns that there was only one view of biotechnology in the protocols adjoining the lab resources, the center began to incorporate more socially significant views of biotechnology. By incorporating such elements as the plays that have highlighted both the 2003 and 2004 educational conferences as well as multiple scenarios that accompany the protocols for both the DNA and protein electrophoresis labs; the center has presented biotechnology in a culturally sensitive manner that gives teachers in the biotechnology community more voice in biotechnology practices. These additions were and are widely acclaimed by the teachers who use the center's resources.

The researcher sees the center as a community of hybrids, scientists that speak and present biotechnology in multiple ways. This would tend to support Latour's (1999) theory of relativistic realism. The center arranges artifacts and resources in ways that are based in a deterministic reality of science, but can be thought of in a socio-cultural manner. This makes the biotechnology malleable enough for many different people to identify and use within the setting of the biotechnology center as well as outside within the larger community. This analysis would also tend to support Feenburg's (1991) critical theory of technology where technology is seen as being both deterministic within a sense of reality, but also seen as socially constructed by members of a community who are using it. The biotechnology center can be seen as a community with scientists and teachers who enjoy producing and using biotechnology in any number of different spaces. All participants discussed the useful and kind personal relationships that have developed between teachers and the scientists at the biotechnology center. It is within these one-on-one relationships that produce lively discourse on the multiplicity of scientific thoughts.

Within the biotechnology center we see the border epistemologies of scientists and teachers working within a community of economic and political forces that have a great deal to gain by keeping the image of technology deterministic, thus supporting corporate or global goals of reproducible science. However, when the researcher considers science as a communal endeavor, he finds the border epistemologies of the scientists and teachers who use biotechnology (both in the classroom and at the center) a sort of hybridization (Carter, 2005; Glasson and Bentley, 2000). As biotechnology travels from the rarified atmosphere of the lab into the more public space of the classroom, the forces of economics or the community, as well as public perception, play a large role in how the image morphs.

Chapter Five: The Private School

Introduction

Granite High School is a private high school in the eastern part of the state, containing approximately 1500 students with only 490 students in grades 9 - 12. There are approximately 180 faculty members, out of which approximately 70% hold advanced degrees. The physical campus of the school houses: 8 computer labs, 2 libraries, a science building with 10 fully-stocked science laboratories for 5th-12th graders, an art center, and athletic center, 2 gymnasiums, 8 athletic fields, 8 tennis courts, and an off-campus site about 10 minutes away with 12 more playing fields. There are million-dollar homes near the school property, and Granite High School's physical setting represents an upper socio-economic nature.

Students who attend the high school at Granite – whether they live nearby the school or have transportation provided for them by either driving or having parents drive them – also mirrors a community with an affluent economic nature. Students attending Granite High School score 150-200 points higher on SAT scores, both math and verbal, than the national average. Out of approximately 300 tests taken by about 200 students, 70% of these students score 4's or higher on Advanced Placement tests. Granite High School is a private school, and tuition for 9th – 12th graders is currently $15,680 per year. Granite High School is accredited by the Southern Association of Colleges and Schools and the state Association of Independent Schools. It also received accreditation from the Council for the Advancement and Support of Education, the Secondary School Admission Test Board, The College Entrance Examination Board, the National

Association of Principals of Schools for Girls, and the Southern Association of Independent Schools.

The philosophy of the high school is three-fold. First, students are challenged academically. Secondly, Granite High School teaches students to take responsibility for their own education and thirdly, the school prepares them for an academic future in the university setting. One element of the philosophy of Granite High School that filters from the kindergarten classes through to the high school is a broad sense of education and the emphasis on academic concepts in multiple settings. A concept that is taught in an English class, for instance, may also be emphasized in another area of the school, whether it emerges in the student center for journalism or through some extra-curricular activity. With this ideology, the staff emphasizes what they call "character development" as an integral part of a student's education. Senior students are required to give what is called a "senior speech," which is supposed to be the pinnacle of that student's personal reflection on the educational experience. The school also emphasized both religious and ethical responsibility throughout the community.

One teacher agreed to participate in the study. Clarisse has taught chemistry at Granite High School for many years. She became interested in biotechnology through its connections with the chemistry curriculum, and has taught some form of it for many years. Bridget, another member of the Granite High School faculty has taught Biology at Granite for many years as well. Clarisse became interest in biotechnology by noting Bridget's interest in the field and her involvement in biotechnology's emergence in the state. After attending workshops from the biotechnology center, Clarisse found a niche for the material within the general chemistry curriculum. She has also taken on leadership positions throughout the Granite High School community, having served as science department chair, and on other school and community committees.

Pre-classroom Interview: Clarisse

Clarisse has been teaching chemistry for more than 15 years. She is an experienced teacher with masterful classroom skills, is the head of the science department, at Granite High School and is held in very high regard by colleagues, administrators, parents and students. When asked how she became interested in biotechnology and why she wanted to attend the biotechnology conference, she stated:

> That is because, my colleague Bridget had talked about how fascinating it was, and I was looking at where biology was going, and was thinking to keep current with new research that is going on (Clarisse, Interview 1, 2004, p. 1).

Describing the students at Granite High School, Clarisse states that:

> The students for the most part are highly motivated, with the usual teen-age hang-ups. But they want to do well. I would say, the average – they are above average in intelligence and achievement compared to the broad public spectrum. So it is a really ideal situation. We have small classes, less than 20, and I teach the advanced math/science section and the first year chemistry course, and then I teach Advanced Placement Chemistry (Clarisse Interview 1, 2004, p. 1).

The researcher then asked how she introduces a topic that is strongly biological in nature into a chemistry curriculum. Clarisse responded:

> Well, I think it relates much more so than I initially thought it would. Initially with my training, the last time I did any biology was a long time ago when I was 16 years old. And since then I didn't do any, however, I know a lot of organic chemistry and some of the chemistry that we do in AP is little bit into that area. There is much you can apply. I don't teach much AP to many kids to the advanced level of biochemistry, but if you can point out to them where the knowledge that you are trying to get started is going, they see more relevance. So you might be teaching basic atomic structure, but if you can say, well, if you can point out to them some organic chemistry, kids will identify with it and relate it and applications will become much more relevant to them (Clarisse, Interview 1, 2004, p. 1).

This seems to be Clarisse's reasoning for including biotechnology lessons in a chemistry curriculum. The current perception by many is that private schools do not live in the same standardized testing environment that public schools do with state mandated end-of-course testing. However, as Clarisse explains students are expected to perform at a very high level of proficiency on the SAT, the ACT and Advanced Placement examinations.

Interested in how including biotechnology could work to improve students' performance on these tests, the researcher asked how a chemistry curriculum that includes biotechnology might evolve. Clarisse explains:

> I have always done protein electrophoresis with my Advanced Placement Chemistry kids. I have not done the flatbed electrophoresis with any of the first-year classes, because all of us do that in biology. But this year

> [2004], we started a new initiative where I am teaching micro-pipetting and the principles of electrophoresis to chemistry students; all of the chemistry teachers are doing that. The biology teachers said we would like to stick some more in, but didn't have time, so I said, I can use it as a method of identification of unknown, methods of separation, I have used that as a comparison of unknowns to standards, which is a general laboratory procedure and then initial separation of the dye stuff, where there are acid/base indicators, so I can tie that in to acid base chemistry and not be completely unknown to compounds. The kids really liked it. I taught it to the 9th graders and they loved it (Clarisse, Interview 1, 2004, p. 2).

As a chemistry teacher, Clarisse has an interest in emphasizing the molecular chemistry involved with biotechnology labs. She wants to help students make relationships between the scientific lab principles for determining unknowns and the chemistry content that students are learning. She wants her students to be able to perform well on standardized tests her students may take including Advanced Placement tests and is interested in making more connections with the biology curriculum.

Clarisse's Classroom

Clarisse's classroom at Granite High School is beautifully designed, with a great deal of light. The class is divided into two sectors, the first consisting of rows of desks, the other a large horseshoe formation of 10 lab benches with sinks, Spec 20s, and gas jets. There is access for the teacher to move in the middle of this square formation so he or she can observe experimentation from all angles. Behind the wall, furthest away from the desks, is a large window that opens into a prep room that runs the length of the entire building. The material resources, both physical and educational, appear to be of the highest quality. Both areas have a hood and white boards, and the lecture area has a projector, which works with the computer at the instructor's table. The Granite High School classes run on block schedule.

The class the researcher observed was a General Chemistry 1 class, which included 6 boys and 12 girls. These were ninth graders in Algebra II or pre-calculus enrolled in Chemistry 1. Students that entered the classroom were extremely well-behaved and seemed to be on-task the entire time. They worked well within their groups, sharing duties as well as sharing a synergy between lab groups, discussing what happened during the chromatography lab with different members of the class. This class consisted of all white students, with no visible racial, ethnic or, from what the researcher was told, economic diversity.

Clarisse began the class by introducing the researcher and then went over the school schedule for that morning. She had the chromatography lab already set up already out on the lab benches, and as students entered, they commented on it as being part of the lab that they were doing today. Students were given hand-outs to explain chromatography theory the day before, but the protocol for the actual lab procedure was handed out as students entered the classroom. These were the hand-outs that accompany the protocol that the Clarisse received in the mail, which are part of the kits designed by the biotechnology center. Some students had questions because they had not had any preparation for the lab work other than the teacher's telling them that they would be doing it that week. However, Clarisse explained that she would answer all their questions as they got into the lab. She explained that the reason she gave them an intro packet was because "now you have something in your head already." Clarisse went over the vocabulary within the handouts that students might not have seen before and tried to relate them to chemistry concepts that had already been covered in class. She then had students pick numbered pieces of paper in order to choose partners.

Clarisse then progressed through the lab by reviewing vocabulary that students would have seen in their readings the night before. She asked the following questions of the class:

> Clarisse: What is chromatography?
>
> Student: A bit like molecular filtration?
>
> Clarisse: What is the purpose of it?
>
> Student: If you have a particle, you can get a separate thing out.

Clarisse continued to ask questions of the students such as, "How would you put chromatography into everyday language?" or "How does it isolate particles?"

Clarisse further explained this to the class, using a drawing she had prepared on the overhead projector and the overheads included in the kit. The overheads showed that basically chromatography is a separation technique, a method for separating out parts of mixture. It was sometimes used to purify a mixture. She explained to the class the difference between the mixture, mobile, and stationary phases, adding, "Color chromatography is what we are looking at this week."

She then spoke about other types of chromatography, TLC, paper chromatography and related concepts. Students then went to the lab stations where Clarisse explained which substance was mobile, which was stationary and which one was a mixture. She reviewed vocabulary words such as “affinity” while students made preparations to begin the lab. The mixture in this experiment was the separation of a mixture of proteins. The mobile phase was a buffer of undetermined type. Clarisse explained that a buffer is a solution that maintains a narrow pH, like blood. The stationary phase in the experiment was the material in the color. Clarisse explained what the word “elute” means by asking students to look at the column in the test tube rack. She said, “You can upset it if you move it around. What do you see at the bottom of the column? This white stuff is the column of beads. The disk at top is to help you not upset columns of beads.”

Clarisse began the lab by telling students how to set up the chromatography columns. She gave directions like, “put the column in the clamp.” A student read out the protocol. Students were reminded about putting the cup underneath to catch both the buffer and the affluent; however, one student still spilled the buffer solution. Clarisse went around and clamped the columns so that students could see the buffer. She used overheads while students monitored the loading buffer; eluting the buffer she instructed students one-on-one about was happening in the lab and constantly reminded students not to let the columns run dry.

Clarisse then used the overheads to explain that different chemicals have different affinities, and that the word “affinity” means different attractions. She explained that it is a little like a tug-of-war. “Some chemicals will be attracted to the beads. Some won’t as much, while some won’t at all. The one that is not attracted to the beads will come out with the liquid coming through". She explained the origin of the word "chromatography", telling the students that *chromos* is Greek meaning color; a protein that is affected in the mobile phase will reveal a color coming through. Sometimes it is a gradation.

As students proceeded through the lab protocol, the vocabulary became problematic. Clarisse went over words like "elute" and "affluent". Then she went over the molecular composition of a protein. Clarisse explained that it is a complex molecule, consisting of a polymer and containing several amino acids joined together. To emphasize functional groups studied in a basic chemistry class, she went on to explain that the unknown substance has acid groups in it, combined with amino groups: "Right at the moment I want you to hassle about (meaning, think about) how they combine together."

She explained that there are three chromatography experiments included in the kits. The first one is called gel filtration, separated by molecular size. Proteins have different molecular masses. She used a whiffle ball metaphor to explain how smaller proteins do pass through the beads while larger ones do not, thereby separating according to size of particles. Then she asked students to read the instruction for this experiment while she retrieved the proteins from the prep room in the back because they were light-sensitive.

Clarisse handed out centrifuge tubes of proteins which she had aliquoted previously. She assisted students in loading the protein into the column and reminded students not to let the column run dry, but to keep putting effluent buffer on it at all times, and to keep pushing the proteins through the column.

Clarisse reminded students that lab goggles will not protect eyes if they are on their forehead. She stated, “Remember what Carol says.” Students and the researcher laughed, as this comment directly related to a poster distributed by a chemical supply company featuring of a picture of a blind girl with a white cane. The poster reads, “Carol did not wear her goggles; now she does not have to.” This poster is in practically every chemistry room in every school that the researcher has visited. Students from different schools have been heard outside of class talking about “Carol” when referring to sight impaired people. It has become a universal slogan in chemistry education.

Clarisse reminded her students to read the instructions of the lab as they continued the experiment. Students had a few procedural questions, but they had good discussions, solving their own problems rather than relying on the teacher to answer questions. Clarisse said, “Stop” again and explained that students had to add loading buffer to the top in order for column not to dry out and continue to run. She reminded students to make some observations while they monitored the column. Clarisse said to think about that little tug- of-war, commenting, “This type of chromatography is not hard.” Students determined that the speed of column is dependent on the amount of buffer on top of the column. Clarisse asked students to predict how many bands students will predict may come out. “Don’t you think this is kind of neat?” she said. Students were interested in what type of colors they might see. Students continued to spill elution they had collected. When a student who spilled materials asked if there were any chemical risks, Clarisse said, “You just want to wash your hands. It is not like you have concentrated acid”.

Clarisse went around and constantly monitored the columns and the students’ observations. Students collected different elutions. She told students that it is easier to see these colors if you have a piece of paper in back of the column. She went around marking on pipettes for next experiment. Students seemed a bit puzzled about the space that they saw between the colors. The researcher observed that at this point, students did not understand the idea that it is the protein spreading out, diluting the color.

The class was very task-oriented. One male student kidded another male student across the room that his column was slow. The teacher laughed and said “Remember what the tortoise said. They will get a wonderful separation”. No students had questioned what would happen if they mixed the fractions together, as has been observed in other classrooms where this experiment has been completed. One student asked, “If you eat it, would you die?” Clarisse said, “Remember you eat proteins; this is not our usual concentrated chemistry lab.”

Students were good about cleaning up although there was a little chatter while waiting for lab to complete. Clarisse completed the lab with a summation, quizzing the students about column chromatography separation by size. She talked about colors and molecular size, how the first one was blue and it was the largest, then brown and then yellow. Showing how to calculate the molecular size by when colors emerged. Inside the column there was a certain volume of loading buffer. She said if students allowed the buffer to go through the void volume would emerged. That has to flow through before proteins can go through. Clarisse then showed a graph that discussed void volume. She explained if it had been collected that in graduated cylinder, students could have figured out the elution volume. They could have then found the concentration of protein in sample by Spec 20 because the reflection of light relates to concentration: “If I gave you proteins with molecular mass, you could have checked off where your volumes were and worked out molecular mass." She explained that when constructing a column, different beads relate to the sample's molecular mass. Clarisse suggested that this is a great type of chromatography to use when separating proteins that have really different molecular masses. "If they are close," she said, "you need a different type of chromatography". Clarisse explained that in research, industrial and health labs, this happens all the time. Someone may want to separate samples but you really end up sometimes with mixtures.

Post-classroom teaching Interviews: Clarisse

In a post-classroom teaching interview, when asked if she would do biotechnology if the kits developed by the biotechnology center were not available, she said she would but that she would limit the lab to paper chromatography like thin layer chromotography or TLC. Clarisse continued and said that she liked this lab because it gave the students a "much more realistic approach to what was going on with biotechnology outside the classroom" (Clarisse, Interview 2, p. 1). When asked again if it fit into her overall scheme for the chemistry curriculum, she said:

> It fits because when we talk about bonding and molecular structure and molecular shape, and we talk a lot about solutions, what types of things dissolve and talk a lot about polar molecules as opposed to nonpolar molecules and how that affects how things dissolve or how things don't dissolve, and that ties in real well with the different methods of chromatography. We talk about the charges within or the dipole within the molecules, so it is a good extension for the kids to see because, well, maybe this stuff is useful that we have been talking about, working with Lewis structures for example and looking at the shape of those molecules

> that we have the Lewis dot structures for ok now can we decide whether this is polar or not and if it is polar then what is it going to do to the way it behaves. What use is that? Well, you can see that you can separate by different polarities and that has been a good tie in (Clarisse, Interview 2, 2005, p. 1).

When asked why the students loved the lab, Clarisse explained that the students are familiar with biotechnology vocabulary and concepts, hearing it both from the public in television and movies, as well as hearing about it first-hand since many of them are familiar with members of the community whose jobs relate to the field. She continued:

> I think it was because, if you say to them, "no this is how they do some of the analysis of DNA and identify unknowns" and apply it that way, you could hook them in that way. They seem to like the more technical things, even if they don't fully understand them (Clarisse, Interview 1, 2004, p. 2).

To students at Granite High School, it seems that technology affords them a perception of information and knowledge that interests them. The students see it as "cutting edge".

In the post-classroom observation interview, Clarisse continues this thought. When asked whether or not students seems to be aware of biotechnology issues before entering the classroom, Clarisse says that they do and usually they have the idea that biotechnology is bad. When asked to explain, she states:

> Kids should be able to look at the newspaper and listen to the television and say, "I know something about that already," or "I can go and find out something about that based on what I know." And viewing it not from the

> simply gut emotional reaction that most newspapers and television programs get you to. It is part and parcel of an informed public that doesn't base its opinion on headline hypes. I think that if we can get the kids to know some of the theory that goes on behind genetic engineering, bioengineering foods and crops, there would be less hysteria and mis-knowledge on these topics that are vital to the survival of the world (Clarisse, Interview 1, 2004, p. 3).

Here, Clarisse suggests that students ideas that biotechnology is bad are emotional reactions that are generated from public perception. By learning the theory, Clarrise hopes that students can see some positive connections between biotechnology and the community. When asked why she thought students thought that biotechnology was bad, she replied:

> I think some of it is economically tied and some of that is valid. You have the bioengineered crops that are very productive, but you can't harvest the seeds, and now you add an economical component to it. There is a tremendous amount that can be done to enable crops to do [what is] is necessary for food to be able to grow in more arid areas with fewer nutritious requirements because they have symbiotic associations or whatever kinds of things you are doing, can go a long way to solve some of the food problems. When Mosanto does some of these things (referring to sterile seeds) to crops, then that is the most cogent argument they have. (Clarisse, Interview 2, 2004, p. 4)

Clarisse explains to the researcher that she herself believes that some of the economic connections with biotechnology that does not serve the community as a whole are valid reasons why students see biotechnology as “bad”.   According to Clarisse, students need more knowledge on both scientific and economic practices of biotechnology. However, the question arises within the interview about why there was no mention of ethics or ethical business-related practices in the lesson. She explained that students at Granite get separate economic education through an endowment, which is an institute for economic education and has been associated with Granite High for along time. She explained:

> It has been on the grounds here; it is not run by Granite but whoever runs it is on the faculty here, as a part-time faculty. So that sort of spills over. A lot of our kids take global economics. It spills over a little in the middle school too. They do things like School Fair where they make stuff and sell it. And we try to couple with that social responsibility (Clarisse, Interview 2, 2005, p. 5).

When asked how she, as a chemistry teacher, would try to couple that with social responsibility, she stated, “If you are going to make money, what are you going to spend it on?” (Clarisse, Interview 2, 2005, p. 4)   She continued by discussing how she sees the connection between chemistry and business: when she explained

> I talk about it, not necessarily with the biotech angle of it, but when I talk about chemical processes. OK, what I really want to know, how much could they get out of a chemical reaction, because I think all of that stuff about stoichiometry, and all that can be so abstract, so why bother, so who wants to know – well, if you were going to make it, your efficiency, well

> if you get 90% yield, then you are in high cotton, whereas you mostly would be getting 50% if you're lucky. So, yes – it is easier for a number of kids to do this (Clarisse, Interview 2, 2005, p. 5).

When asked whether she thought the biotechnology center shaped any economic ties with her or her classroom that may influence her lessons, she replied no.

When asked how including micro-pipetting and other flatbed electrophoresis practices in chemistry helps the overall scientific curriculum at Granite, Clarisse explains that the practices are all separation practices and can be modified in ways to include the current chemistry topics. The Advanced Placement Biology classes have specific labs that must be performed, in order for students to do well on the exams. The Advanced Placement Chemistry classes do not have a set of labs that must be preformed but instead have topics that must be covered. This gives Clarisse more leeway in adding seemingly extraneous lab work into the curriculum, although she assures the researcher that it is not extra, but enhances topics already covered. It also prepares students who are taking the Advanced Placement Biology exam much more of an understanding of the uses of electrophoresis. It also gives more access to costly biotechnology equipment that was bought several years ago to be used by teachers other than just biology teachers.

The way that Clarisse talked about teaching suggests that she and the community hold attending workshops and introducing new "cutting edge" technology into her curriculum in high regard: "Our administration is very, very positive for the faculty to go and do things like this. It is perceived as an added advantage that their faculty have like AP stuff, training" (Clarisse, Interview 1, 2004, p. 4). She continued to discuss how the community perceives it, too:

> The parents see it as an advantage too. Like on parents' night, if you tell them what you did that summer, and when they say, "are you going to do that in the classroom?" and I say, "well, not all of it," because I don't think where we live the school community would like it if I dragged in a carcass, but some of the things we will. So they appreciate the fact that they are interested in expanding what we know, so then we can pass it down to their children. Students like it, they really like it. They think it is a big privilege because it is coming from a college (Clarisse, Interview 1, 2004, p. 4).

When asked how she saw her role as a teacher and the role of the scientists at the center being different, she suggested that she saw her role as disseminating information to students for the scientists. In this way, she sees her work as a whole practice of science being connected with the public.

Analysis of Clarisse's Classroom

After interviewing Clarisse, questioning her about her teaching practices as they include biotechnology and watching her and her students in action during a gel chromatography lab, the researcher discerned several important elements. First, Clarisse emphasized the molecular biology included in this experiment. The researcher was very impressed with the depth of the lesson by including some very abstract and complex molecular issues. Also interesting was how Clarisse emphasized industrial and research-oriented connections with the lesson. During each class, she made a special effort to elicit a discussion about how this type of chromatography was a realistic example of how biotechnology and chemistry were used in the fields of medicine, research and industrial job markets. She spoke not only about the connection between chemistry and the percent yield that a prospective employer may be looking for during her interviews, but also about it in her lessons as she pointed out research possibilities connected to this science.

Paradoxically, even though she mentioned during interviews that she saw a cogent argument to an unethical business practice of Monsanto to produce and distribute sterile seeds, she made no special effort to make a connection between embedded ethical discussions in science curriculum and such practices. Clarisse believed that developing lessons that emphasize strict scientific knowledge, separated from its social moorings, can alone give students the tools necessary to weed out complex socio-scientific issues dealing with biotechnology. What quickly emerged is a biotechnology lesson that is void of any social or economic relatedness. Along with this, students at Granite High School receive an economic education that seems to support a free market economy. What further emerged is a type of biotechnology lesson that the researcher interpreted as positivistic in nature. Here biotechnology equipment was used deterministically and there was no social connection made between the humanistic endeavors of the scientists who use them or the community in which it is situated; only economic endeavors.

Clarisse saw her new knowledge as being advantageous for her as a teacher, as do administrators, parents and students, who see her as having more power and knowledge within her school community. Because this community is one where most people are familiar with biotechnology practices, the inherent power that develops from the public's perception of using biotechnology in medicine or research is then transferred to her. Supporting the Advanced Placement Biology curriculum by embedding other chemical concepts within biotechnology lab protocols, she not only gives students the ability to delve into a more complete understanding of the lab practice for students who are college bound and possible future biotechnology employees, but she also increases student ability to do well on standardized tests that give students at Granite High School higher academic prestige.

Chapter 6 – The Public School

Introduction

To learn more about the connections of biotechnology with the classroom, the researcher attended classes at Little Rock High School. Little Rock High School is located in the southwestern part of the state in a relatively rural setting. It is a large high school consisting of about 2,200 9th through 12th grade students. It is the only high school in that county and pulls students from many different communities, including affluent communities near a lake where housing costs are very high, and agricultural communities where housing costs are very low. The racial or ethnic diversity of the student body is relatively low, consisting of 86% white, which is higher than the state average, 13% black, and 1% Hispanic, Asian and Native American.

However diversity within the student body does exist within the economic realm. Approximately 22% of the student body receives free or reduced price lunch. Almost one quarter of the student body receives this benefit and is from the lower socioeconomic communities surrounding the school. These students attend classes with at least the same percentage of students who live near lakefront property and are of the highest socioeconomic level in the county.

Little Rock is located not too far off the interstate and surrounded by small businesses, fast food restaurants and churches. Little Rock has a campus-designed high school with numerous brick buildings with winding pathways and hallways. The researcher visited two of the science rooms in one of the farthest buildings from the main parking lot.

The science classroom where the two participants teach is small, a bit cramped actually, and has had very few updates since the 1960s. Black top lab stations dominate the back half of the room and a blackboard with an instructor's desk and about 30 individual metal desks face the front of the room.

Two science teachers at Little Rock were observed and their teaching practices analyzed. Ellen and Francis both teach sophomore general and honors level biology students in a 4 by 4 block scheduling environment. Ellen has taught at Little Rock for three years and has lived in the county all her life. She holds an undergraduate degree in biology and has worked in the private sector in an educational setting before making the change to enter the classroom. She is intimately aware of the small communities that make up the county and many of her students know her and her family. She has strong family roots in this county and is raising a family there herself.

Francis is an untenured teacher who is new to both the school and the county. She has been at Little Rock for two years, and previously worked in the private sector for one year before going into teaching. In her words, she was "fresh out of college." She is the youngest person on staff in the science department of the high school. She has an undergraduate degree in biology from a local private college. Both Ellen and Francis found a flier for a biotechnology conference at a local university while they were cleaning up the science prep room and decided to pursue the workshops. The researcher met up with Ellen and Francis at the biotechnology conference and both showed an interest in being included in the study.

Ellen and Francis at the conference

Ellen and Francis attended the 2004 conference held by the biotechnology center and agreed to participate in the study. When asked why they wanted to introduce biotechnology into a curriculum that is already very full, they each stated the importance of biotechnology being a "cutting edge" science and that the hands-on materials would be beneficial for the students that they taught. They both also suggested in the beginning that one goal of taking back biotechnology to their classrooms was to generate interest in advanced level biology class offerings with the student body, administrators and parents. They were interested in either an Advanced Placement Biology class or some sort of second year in biology emphasizing biotechnology. The school had offered an Advanced Placement Biology class in the past, but not recently.

After that, their goals for attending the conference were somewhat diversified. Ellen stated "We need to integrate modern biology into our curriculum, and we don't do a whole lot of biotech, so I need to refresh myself because when I was in school there was no such word as biotech" (Ellen, Interview 1, 2004, p. 1). When asked what she meant by modern biological concepts, she stated:

> Oh we are talking forensics and genetics and DNA, the discoveries in DNA sequencing and fingerprinting, it is all relatively new stuff as far as I am concerned, so I need to understand it so I can teach it (Ellen, Interview 1, 2004, p. 1).

When asked the same question, Francis adopted a different reason. Again, Francis was a new teacher and had just graduated from college. She had been exposed to biotechnology in her undergraduate work as well as having peripheral awareness through her pharmaceutical sales experience. She stated that by attending the conference, she was able to get access to the biotechnology equipment and would able to include materials in her curriculum that the school would otherwise be unable to afford.

Both teachers had previously completed DNA spooling laboratories as well as computer-based labs on the internet in their classes with great success. They both discussed how successful the DNA spooling lab was with their students and wanted to include more laboratory experiences in biotechnology in their classrooms. However, their reasons for attending the conference were somewhat different. Ellen, being more experienced than Francis, felt she needed more domain information about biotechnology itself, whereas Francis was looking for more pedagogical and practical classroom instruction. When asked how they each heard about the biotechnology conference, Ellen stated that the school's science department had found an old flier in a previous teacher's mailbox. She checked on the web, found the biotechnology center's site and registered.

They both attended mostly the same workshops including a pre-conference boot-camp session. The boot camp session was designed to bring new teachers "up to speed" with the simplest biotech vocabulary and procedures. When asked what she thought about the boot camp, Francis stated: "I really liked the first thing we did, the DNA extraction we did with the strawberries, because it went so much better than ours. It was more hands-on" (Francis, Interview 1, 2005, p. 2). However, Francis was pleased with experience in the boot-camp because the instructor was teaching it in a way that was more inquiry-based than she was used to using with her students. She states:

> The way she [the instructor] was describing it to the students was different from the way I would describe it. I have to explain everything to them

> [her students] before they get to that point. So they get the big concept. She [the instructor] did it in segments, she did a little bit of history, broke down the words, talked about the background, made them go back to prior knowledge while asking questions and then you do a little segment, but she wouldn't actually explain what the finished thing was yet. So the kids and we would still be wondering (Francis, Interview 1, 2004, p. 2).

She continues by explaining how she sees herself instructing her classes differently:

> I always get ahead of myself because I get so excited, and so the kids get overwhelmed. So by the time they do the lab, they have forgotten what is going on. Because once you explain it, once you say it the second time, they are 'oh well I already heard this and I am not going to pay as close attention.' So if we add more mystery to it, like she did, maybe the kids will pay more attention to it the first time they hear it (Francis, Interview 1, 2004, p. 2).

Another idea that begins to emerge here is how a teacher's personal excitement or interest in the laboratory directly affects curriculum design. If a teacher likes the scientific concept or has some affinity to the subject, then he or she is more likely to use it in the classroom. Both participants felt that biotechnology had a place in the biology curriculum, and a place in the knowledge bank of the community. Both kept suggesting that it was an important biological concept that all students should know. It was this personal interest, excitement and commitment that kept participants centered on using biotechnology in their classrooms to some degree.

Ellen was equally satisfied with the boot camp. She states:

> It was fun. We did the DNA extraction we did (previously) and it was simpler than what we had designed for our experiment, so we got some shortcuts there, and so oh that's why that did not work there or, and we were able to give some insight into what worked for us. And just being there and being able to do it, like I said, I have never done this stuff before. We didn't do this stuff when I was studying genetics, we were just doing punnet square and we knew that DNA had a double helix and that's about it. So getting in and doing it, it was like being at school again and I really enjoyed it (Ellen, Interview 1, 2004, p. 2).

Here, Ellen suggests that her main goal from the conference was to understand how DNA and biotechnology actually work. The fact that she is interested enough in the curriculum to want to take time out of the summer to learn about it herself, signifies that she is deeply committed to using it the classroom. Ellen also seems to be a teacher who is always looking for good resources for her classroom. She stated that she was always been one who always knows where the resources are and tried to use them. She mentioned that several conference instructors were now on her "favorites list" on her computer at home.

Both Ellen and Francis attended several other workshops. Ellen suggested that a workshop on Saturday morning was very beneficial. It was called "The Case of the Crown Jewels." It is biotechnology brought to different schools on a bus. "They gave us a whole bucket of stuff to bring back" (Ellen, Interview 2, 2004, p. 1). For example,

We got the packets, we got the, she [the instructor] gave us markers and free scissors and roll of tape and good scissors. Teachers don't have good scissors, so these are like getting my name on them with nail polish or something so it won't come off. Crime scene tape, you know it was really…very cool…I was very impressed and it was fun too" (Ellen, Interview 2, 2004, p. 2).

Ellen also discussed the activities that they experienced:

> We did the activities that the kids would do and some of the activities were just so simple. Like we did the restriction enzyme cut of DNA and all she did was she took people out of the audience and gave us cards each with a letter of a nucleotide base on it and wherever the line…she said ok class we are going to cut between the Ts and the As, so she went down the line of us that were holding these cards and we had these big paper scissors which we got, our own big paper scissors and we were cutting between the Ts and the As and she said now if I turn on the electricity, who is going further into the gel, and she switched the lights and we all acted like we were getting electricity and we all started to float as if we would in the gel and of course the smaller pieces went further than the larger pieces and it was the simplest thing, but it was so excellent. I really enjoyed it. (Ellen, Interview 2, 2004, p. 2).

Here Ellen is suggesting that it wasn't the high tech equipment that impressed her or that she felt like would impress her students nearly as much as simple techniques that would explain a concept.

Francis suggested that she probably would not go back to the conference next year. The reason she attended this year was to refresh her own technique and gain access to the equipment that the Biotechnology Center had to offer the kids. Ellen suggested that she too would probably wait for a year or two before returning just because she wanted to explore different workshops during the summer in order to keep diversified in her domain knowledge.

Pre-observation Interview: Francis.

Francis had previous experience with electrophoresis in her undergraduate work and felt her domain knowledge was suitable for understanding the protocols accompanying the lab. When asked again what importance did the workshop play in her biology curriculum, she explained that Little Rock did not have the budget necessary to offer such a costly lab without the help of the biotechnology center's loan program. By utilizing the DNA and Protein electrophoresis kits, Francis was able to bring demonstrate the importance of biotechnology in the lives of her students. She states:

> It is more important for the lower level classes. These students are having a hard time wondering why they are in biology in the first place. So they really need the hands on experience to get them excited, because if they are just sitting there, they have not reason to memorize, but they can't really fake a gel. This is a process they have to go through and are excited about because the see it on *CSI* and it gives them a chance to feel like an achiever." (Francis, Interview 1, 2004, p. 3).

She was also very interested in diversifying the biology course offerings at Little Rock to include an Advanced Placement Biology class. She suggested that she would be interested in teaching it.

There were other, more personal reasons why Francis went to the conference. She informally explained that she looked very young and that she thought the administrators, parents and school colleagues saw her as possibly not knowing as much as she did because she looked, dressed and acted younger than others. In speaking about another positive reason to utilize the kits, she explained in subsequent interviews:

> You know, I don't know what they think of me already. I am baby-faced; I am not given as much credit as the older teachers, even if we started at the same time. If you have more years or if they see you as more mature and authoritative, and serious about your job, and I think just the way I carry myself, that it might give the impression that I am not a serious about my job as some of the other teachers. Well in fact I am - I just don't have an urge to wear a suit to work, or heels or any of that fun stuff. So I think doing things like this shows administrators that I know what I am talking about, I am in touch with technology, and the kids are getting it so I am doing my job. So I think it reassures them that more is going on in class, because I think when they walk by, they see peering eyes, when we are doing the review game like you say yesterday. I see the eyes looking around because the kids are talking to each other, yeah, they are talking about the questions, but they can't tell that because they are looking through the door. And then you have kids walking around, because they are switching seats, it is actually organized, but to the outside observer, unless you are in the classroom and hear what is going on, it doesn't look like that. So I think that says, oh they are doing more than just wondering around and huddling in groups, or just listening to lecture (Francis, Post Interview 1, 2004, p. 4).

By bringing in new scientific labs, Francis can show her interest and worth to school administrators, who may not see her as having as much domain knowledge as older, more experienced teachers or older faculty members in general have.

When asked to describe the students that she teaches, Francis suggests that she had both academically motivated and unmotivated students. She reports:

> I had a couple of daddies in my class, they are about 15 years old and had a couple of kids who were repeaters. I had some kids who could have done high level work, they just did not want to. I had a lot of them in my general classes a lot of ADHA students and at the beginning of the course I had a handful of students who were going to enroll the GED program. In my TA (honors) classes I had students who were used to getting A's and didn't have to work for them because the work came easily to these students (Francis, Interview 1, 2004, p. 3).

Francis did say that when doing the DNA spooling and website lessons last year, the classes had discussed some ethical and economic issues concerning biotechnology, but she had not introduced it explicitly into the curriculum. When asked about any economic ties that she saw were visible within the Biotechnology Center and might play a role in how she would develop her lessons, she expressed awareness of one connection. During the conference, she said one of the workshops was instructed by a person who was trying to "sell" them the equipment and lessons that his company had produced. When asked whether she had seen any connections to the Center itself, she replied no.

When asked how she saw her role as a science teacher in relation to the role of scientist at the Biotechnology Center, Francis said that she saw the scientists doing real science:

> I don't see much of a connection. She [the scientist] is doing research, she is in her own little room, and their research is so specific that it goes to one little section of the community, and I see mine as you know, she is impacting many people. I am going to be out in the community, you have the parents coming in, special events, so you are going to impact more people. She may come up with some great discovery. It will be years until it filters down to the regular people (Francis, Interview 2, 2004, p. 7).

Francis saw a clear delineation between her role as a science teacher and the role of scientists at the biotechnology centers role in relation to biotechnology:

> Whatever I do goes directly into the community and I get to see the results. I can't see myself as a scientist, as a teacher. Scientists are up there discovering and you are more focused on your interests, and as a teacher, yeah, you are teaching science but you are also being baby sitter, mommy, guidance counselor, because even if you have a mutli-disciplined class, you are still having to do the whole self-esteem thing with the kids and you are worrying about how are you grading, how does this impact their future, how does this impact their self-esteem, you are trying to do all this stuff and you can't concentrate just on science (Francis, Interview 2, 2004, p. 7).

In contrast to the level of scientific inquiry possible in a secondary classroom, Francis suggests that there is a strong delineation between the science that is completed in labs at the biotechnology center. She suggests that the scientists at the biotechnology center are not connected with the community, while her role as a public school teacher is. Francis also suggests that the empirical science that the center's scientists conduct does not address the "whole child". She implies that the center's work addresses purely empirical concerns. Instruction at the public secondary school inherently carries the burden of the student's emotional as well ass academic development. She continues:

> Science is there because you have to teach it. The main thing is you are having to do all the emotional problems and developmental stuff (Francis, Interview 2, 2004, p. 7).

Francis does not see a connection between science in the lab and how it plays out in the classroom. Francis believes that SOL end-of-course exams will push biotechnology curriculum to a lower priority in the state's biology curriculum. When asked if the SOL asked more questions on biotechnology, and would it make a difference in her instruction, she replied "yes." Interestingly, when asked if she thought biotechnology was important enough to deserve more emphasis on the SOL exam, she replied "Not really."

Francis's Classroom Teaching

When the researcher arrived at Little Rock, Francis remarked that because of time necessary to cover topics like protein synthesis in preparation for state-mandated tests and, because of the poor behavior in the class, that the DNA electrophoresis lab would only take place in her 2nd and 4th period class at the school. Third period class would not participate.

The day before she does the DNA electrophoresis lab, Francis began the class with a quick discussion of the strawberry extraction lab. This was a lab that was included in the protocol distributed by the Biotechnology Center and that she did in the boot camp workshop during the summer. She began the class with a quiz on electrophoresis. Most questions were pretty simple and were extracted from the reading the students were supposed to do at home. She told students that those students who failed the quiz would not get a chance to complete the DNA electrophoresis lab the next day. Several students seemed worried. She reviewed plant cell parts by drawing on the overhead and discussing what students had to break in order to get to the DNA. She told students that they would have to squish the cell walls, using soap and salt (what the buffer is made of) in order to break the lipid. She demonstrated how one person in each group should get the equipment, and how to get as much air out of the zipped bag as possible. Francis used the worksheet provided in the kits and the protocol book to elicit questions and possible outcomes from students.

Students began squishing the strawberries and answering the first couple of questions on the sheet. Some of the students commented on how they should "clone Francis." She said, "Right, like you want another me" and they all laughed. Then the student discussion turned to the television series *The Simpsons* and an episode where an evil twin was cloned. Francis then poured the ethanol on the beaker while she reviewed the polarity of the water molecule. Students then used toothpicks and extracted a huge amount of DNA. The classroom became alive with enthusiasm as students immediately started asking questions like, “Can we touch it”, or “Can we eat it?” The teacher said that students could touch it. Then students wanted to know how to make extraction fluid so they can do it at home on vegetables. One student asked how this compares to extracting DNA from a human cell. Francis said that it is a bit more complicated. One student sarcastically suggested that “You can’t use cheesecloth,” and everyone laughed.

Francis then had students practice pipetting with practice stations provided in the kit. Students commented on the small the amount of dye necessary. One student said “It would be cool to be a forensic scientist.” She said “It looks fun to do.” She was one of the students who was afraid that she may have failed the quiz from earlier in the period and not get a chance to complete the lab the next day. She said that she loved *CSI* and that it would be “cool” to mix chemicals.

The next day Francis began the actual DNA electrophoresis lab with this class. The researcher was told by other teachers that many students throughout the school were excited about this lab. The students had been talking about it for weeks and were talking about it in different classes. The researcher was also told that the classroom would have frequent visitors including the principals, assistant principals and other teachers. Francis had set up all equipment for the students. She had eight set-ups on three lab benches, two set-ups on one bench, two set-ups one the second bench and four set-ups on the third bench.

Francis told students because she liked them all, everyone would get to do the lab, regardless if they really passed or not. She went over the correct answers for the lab questions and how she made the gel, talking about how a bad gel could be a variable in the experiment. She talked about loading the well with the micro-pipetors, loading samples, and how they all looked the same in the wells, so students should record what was in each well. Many teachers who did not complete this type of biotechnology lab in their classrooms were really excited about this lab work, even teachers who did not go to the conference or have much experience with this DNA electrophoresis.

Students loaded the gels well and were excited about getting their results. They worked on guided practice sheets provided by the Biotechnology Center while they waited for gels to run. The guided practice sheets talk covered restriction enzymes and other elements of the protocol. Francis was very excited, perhaps more so than the students. Francis came around and told each group about the dye in the DNA samples. Students were enthusiastic about the equipment and were well-behaved during the waiting process. Francis seemed concerned about getting a good result from the lab.

Several other teachers came in to observe as well as several administrators. The principal came in to the classroom to observe. He told the researcher that the budget is “really tight” and having “free hands-on stuff” is so important. Students drew the half way mark on their gels while Francis went over the crime scenario of Fluffy’s Bowl that is included in the protocol from the center; she subsequently told students which band of DNA they should compare. Other administrators were now coming in asking for the solution to the crime. Previously visiting administrators had spoken to others in the main offices about this group is “solving a crime.” They seem excited, too. Francis had students who could stay after the bell ring stay to help dye the gels. Several students did.

The next day students in Francis’s class analyzed the gels. She gave instructions for one person in each group to add some water to the gels which they had already dyed and to rock them back and forth, pouring off the water (i.e. a process called de-staining).

The lab was set up with the numbered gels in their boxes and a light box by each container that contained a gel. Students entered the classroom a more noisily than previously. The students quickly got their instructions out and read the protocols and instructed other students in their groups what should be done. They answered the questions that were provided by the lab protocol from the biotechnology center. Francis walked around and reminding students de-stain their gel. Students were talkative during the de-staining process, so Francis walked around and reminded students to de-stain their gel and instructed how to put the gel in the bag, and where to put the materials once they finished the de-staining process.

Students were to be pleased with their results. “That’s awesome,” one student in one group said. “I think ours broke,” said another one. One group was already looking at their gel on a light box and is studying it. One student from a group said: “I want to squish it.” Students were then instructed to get out their lab sheets and figure out what marks meant what. They compared it to the drawings they made the day. “That is Fluffy” said one student. Students asked about the DNA ladder again. Francis went around explaining to students that a particular line was a sample from Fluffy’s bowl, this is a sample from the neighbor’s cat and so forth. Once students understood how to read the gel, (for example, what each column represents), it was an easy jump to figuring out which cat was eating Fluffy’s food. Francis let her students take their gels home.

Post-observation Interview: Francis

Francis was very pleased with the outcomes of the electrophoresis lab. She thought that the equipment worked very well and that all her students enjoyed the lesson. She explained:

> I loved it, because it got the kids excited, more so than I would see them excited for a regular lab. Usually on lab days, the students look forward to them, but they are not jumping out of their seats ready to do lab. Because most of the labs that we have are still paper based, kind of glorified worksheet labs. And this was their first real lab, where they actually got to use technology that they see on television and it is not what they consider to be a "baby-fied" [too elementary] lab. It was a grown-up laboratory situation where they had to be careful and they had to use special equipment that they had never used before and even the micropipetors were special equipment and they practiced before hand and I think it made it seem more exciting because it built up anticipation (Francis, Post Interview 2, 2004, p. 1).

When asked about the third period class that could not participate due to behavior, she replied:

> Yes, I was very disappointed because there were a couple of kids in there that really wanted to do it and they were genuinely upset when they couldn't do it, they were genuinely excited when they came in and they sat down and were 'thanks a lot, guys, for messing up so we can't do the lab.' It is kind of upsetting because the kids that screwed it up for everybody didn't act concerned. I don't know if that is an act they are putting on, or if they didn't care. If they truly didn't care, it didn't punish them and it did punish the kids who were concerned (Francis, Post Interview 2, 2004, p. 5).

Curious about the behaviors that made a student in her third period class not able to participate in the lab, the researcher asked Francis began to describe the social structure of her classes. She replied:

> They are all TAs, even third period, except, I think my fourth period is generally more financially well off. It is weird. In my third period I have a lot more diversity whereas in my second and fourth period, they are all white students. (Students in my second and fourth period classes) are all in the same kind of cliques. They share the same kind of I guess it would be a preppy mentality. And in my third period you have more, more rednecks, then you have the group of black girls that tend to stick together, they are louder than the rest of the kids, they behave different, and they try to fire up the rednecks and then the other kids, it riles them up. They seem more diverse in the way they act. Some kids who are quiet, some kids who have been suspended, you have more some of my problem students, and the office calls for a student for something they did. So I have more problem makers in that class. They are not advanced because of their intelligence; they are in the advanced class because their parents don't want them stuck with the other behavior you find in the general classes. So I think a lot of them waivered into the class (Francis, Post-Interview, 2004, p. 6).

Francis was very pleased with the attention her classes received from administrators. Again she reiterated to the researcher that she thought it would help her standing with the educational community to be seen as a teacher who used technology in her classroom.

When asked why she did not explicitly teach any socio-scientific or ethical issues into the class, she mentioned that she did not have time. She suggested that the lab already took two to three days out of the curriculum to do and that they needed to move on to new concepts in order to cover as much information as necessary before the SOL end-of-course tests.

Analysis of Francis's Classroom Teaching

Francis did make some molecular connections between material on organic molecules talked about earlier in the year and the DNA electrophoresis laboratory in class. It gave students the opportunity to review previously covered material as well as seeing it in a slightly different way than just out of the book or by molecular modeling. The most important feature Francis felt that the lab brought to her classroom academically was to get her students excited about biology. By seeing a lab in a real world perspective, students could derive the importance of learning and doing biology at Little Rock High School.

Personally, Francis was very explicit in wanting to incorporate biotechnology into her curriculum. She stated that she looked, acted and dressed younger than most of her colleagues. She wanted to be perceived by her administrators and peers as knowledgeable, and by incorporating a type of science that was seen as complex, technical and fascinating to the public, she did just that. Every administrator visited her room to see this *CSI*-like crime lab that the biology department was doing. Administrators made a strong connection between her abilities as a teacher and her ability to gather expensive resources that could be used in their school.

Francis did very much categorize students in her classes by academic interest. Those who had a "preppy mentality" were those students who would strive to meet the academic challenges that Francis presented. Those who did not hold interest or find meaning in her lessons were categorized in somewhat negative ways and were, in the case of her third period class, blocked from access to participation.

Even though Francis was somewhat aware of the economic connections that might stretch from the Biotechnology Center to her classroom, she made no attempt to explicitly connect any social or ethical issues with her students. Even when given opportunity by the students' own discourse, like the conversation about cloning, Francis chose not to use it as a spontaneous springboard into an ethical discussion.

Francis said that she would probably use the kits again in her classroom, but that she probably would not attend another conference. She was interested in moving on to new ideas and labs she could bring back to her classes.

Pre-observation Interview: Ellen

Ellen attended the conference with Francis and both articulated how they would use the laboratory practice in their classes, but Ellen explained that in order to do that, she would have to refresh herself on forensic and DNA genetics. Ellen spoke about how she felt they did not have the equipment necessary to talk about genetics or forensics in a way that would either make biology meaningful to the students or to prepare them adequately for SOL end-of-course exams. When asked why she felt like her students even needed to know about DNA electrophoresis, she responded:

> Well, if you are going to be a parent one day, that's important, you need to know background and genetic mutations or if you are going to be a farmer,

> you need to know about genetic diversity in crops now, experimental designs, so and hit every population that we have. We've got the rural, we've got everybody, we've got the rich to the poor, to the ones who don't care about school to the ones who want to work on the doctorates (Ellen, Interview 1, 2004, p. 1).

Unlike the previous teachers interviewed, Ellen was also very concerned about the importance of citizens being informed about the implications of biotechnology.

Ellen's favorite part of the conference was the boot camp. She said that she needed it to refresh herself on biotech concepts. She kept remarking that she had never done this type of science before and how much she liked it. However, when asked how relevant what she learned at the conference was to her students, she stated that she had thought about that:

> I was struggling with that answer. I think it is very relevant because I teach from the perspective of how does biology help us, why do we need to know it? So I think it is very relevant as far as current events… I want them to see that science is complicated but also relevant at the same time. I want them to have that understanding that this is what people are doing for your benefit and for society's benefits. Now Joe Schmo over here on a cow's farm [needs to know this] so I try to make it so that he can. They are genetically altering their cows, they are genetically altering their corn. So they need to know how it works, or an understanding of why it works (Ellen, Interview 2, 2004, p. 4).

Ellen seems not only to be keenly aware of biotechnology issues that affect members of her community, but she is also eager to share these connections with her students. From her interviews, Ellen is cognizant of the complicated aspects of science, and she aspires to teach in a manner that elicits a communal perspective. Her experience at the biotechnology center conference increased her knowledge of content, giving her the tools to construct a dialogue emphasizing the communal aspects of this content with her students. Before completing the lab with her students, Ellen anticipated that her students would incorporate their worldview within classroom discussion.

The researcher then asked Ellen if her students would be as interested in these issues as she was. She responded favorably:

> I got the farmer. I got the lower level, socioeconomic kids whose parents say to "go to school so you are out of my hair." I got the kids who can't wait to get out of school, get married and get pregnant, and then I got the ones who are excited and I also have the ones who are excited about science, but yet restrained because of their faith. That is a real challenge. I didn't realize I would meet so much of that. I guess I should have considering the Bible Belt. It has been interesting. What is the ethical question there, are we supposed to be in there altering this stuff, on the other hand have we already created an environment where we have altered it and we are fixing it (Ellen, Interview 2, 2004, p. 4).

Unlike her teaching counterpart at Little Rock, Ellen believes that her students do find connections with the content that they are exposed to in the classroom. Here, she suggests that many of these connections intersect with students' worldviews since she acknowledges that her students may attempt to frame scientific knowledge around their religious beliefs. The very essence of biotechnology can run counter to certain fundamentalist Christian beliefs. A segment of Little Rock High School's student population, in Ellen's view, might already possess a framework that would lead to problematic cognitive scaffolding of biotechnology concepts.

The researcher then asked Ellen in what direction she would be using this biotechnology knowledge in her lessons. She discussed how she agreed with the SOLs as being a good thing and how she saw her own domain knowledge as well as the domain knowledge of her students becoming clouded with new ethical issues that would emerge through explicit discussion of them in the class. She did not feel this was a bad thing:

> Oh well, I just kind of agree with the SOL, it is not a separate issue anymore, our world is so technology-based now and so dependent on the information that technology can derive for us, that it is a part of society. It used to be, you know, "Oh you are in science" or "you have a totally different way of thinking." But that bioethics class really opened up my eyes, saying it really is clouding up the court systems, that is why the forensics teams are so backed up because we have all this science and legalities that are going on. So how to introduce it to a kid…hmm….discussion regarding case studies, or working up a reading list so they can have some sort of insight into how it is starting to affect, for instance there are a lot of fiction books out there now, all based on

> biotechnology, Richard Cook's series or *Outbreak*, and *Shock* and all that. I guess that is the only way I can think of right now that I could introduce it to them, you could have them explore it on their own rather than have you guide them through it, because I am still exploring it myself (Ellen, Interview 2, 2004, p. 6).

Of particular interest to the researcher, was that here Ellen not only suggests that the community may take on a type of hybrid thinking when it comes to ethical issues brought on by biotechnology, but also admits her own confusion on how to explore these. She continued:

> I started last semester with my first year teaching. I came in saying ok, we are going to have some discussions that you guys are not going to like. But it is my role as a scientist and not just as a teacher, to give you all the aspects…to look at, to give you the information to make up your own mind. Because our students are taught one thing, and there is no other side. And if we can show them all the sides of a coin not just the front and back but everything that goes round the outside in- between, we will hoping they will make them better citizens (Ellen, Interview 2, 2004, p. 11).

She also made a comment that introducing biotechnology into her curriculum would make students better citizens. She explained:

> I think if I can relate the technology as closely associated with this whole "we are all human type thing", then maybe some of those cultural and societal differences will begin to diminish. It will take a while. But if they

> see them the same, especially teenagers, if 99.9% of them is the same as little Bobby over there who is in a wheelchair, or has a different color skin, maybe it will make them think. Maybe it won't make them think now, but maybe it will help them think later when they have to stop to help someone on the side of the road (Ellen, Interview 2, 2004, p. 12).

Ellen articulates here that technology and science are closely connected to human endeavors and experience including cultural barriers. Ellen's primary responsibility is to content. She addresses this by relating the empiricism of science and technology to the student's worldview through a framework of shared communal experiences. And underlying that, Ellen is defining citizenship in a manner that supports empathy and understanding.

Ellen discussed how she thought a great deal of the research and economic connections with the biotechnology center affected her teaching but seemed unable to define her responsibility clearly:

> If you look at it, and I have only been for one year, but I have looked at two different conference pamphlets. We initially signed up under 2003, not knowing (laughing), but the classes were the same. And I don't know whether that was what their kits were providing or that is because that is what the money that provides what is providing the kits is providing, or that is the research they are doing, or that is all that science is limited to right now and that is as far as we can go. Because I don't know that much about this stuff and I wouldn't even know if we were being limited, you know, this is all new to me, so that technology is there, I can see some

> extensions, but I can't see the whole broad picture that needs to be looked at, and I know we don't. I think we are still trying to make all those links. So it is like a big circle, going round and round. I don't know. But it is a fascinating discussion (Ellen, Interview 2, 2004, p. 8).

Ellen realized that the center is situated within several spheres but was unable to acknowledge clearly the economic component. She understood that the kits in some way carry the intentions of corporate stakeholders, but being so new to biotechnology herself, not having strong domain knowledge, Ellen was not sure what all these connections are and how to identify them as of yet. That is, Ellen was not comfortable with how economic forces would shape her classroom instruction.

> I can remember back, I don't think it was until upper level college that we were getting into discussions and issues about different things. It was all, this is the science, cut and dry, black and white, if your lab didn't work out this way, well you did something wrong, rather than being open ended. Actually that is probably why I went into the environmental sciences, is because that was where the discussions were at the time, you know in the late 80s, we were looking into the problems of pesticide usage and the greenhouse affect and at that time, that is what intrigued me because we had open discussions about that so I think that is why I went that avenue. Plus I was outside plopping around in the mud. If we had had open-ended discussion in immunology class, I may have done a little better (Ellen, Interview 2, 2004, p. 8).

Here Ellen is suggesting that she previously had an interest in areas of science that have been represented with a more communal spirit. She describes how her own learning as been centered around making realistic connections between the community and science. For example, ecology classes were interesting to her because she could see connections between the science and its affect to the surroundings of the community. She admits that she may have been able to understand content of other scientific disciplines if these types of connections had been emphasized. Because she interprets science as a complex, human of endeavor, Ellen may be more likely to make these connections within her classroom in the future.

The researcher then asked Ellen how she saw her role as a science teacher in relation to the role of the scientists at the biotechnology center. She replied:

> I think…no. I think scientists are teachers in a way. They are finding out new information and they are sharing it. And I think that is what teachers do. My philosophy as a teacher is that you don't pound it into their heads, you present it in such a way that they want to have it. I don't think there is a difference between science teachers and scientists. I think there is a difference between science teachers and English teachers. But as far as science teachers and scientists, no. I think what we do in the classroom, we are taking information from our own kids and we are coming up with hypotheses on how to fix that (Ellen, Interview 2, 2004, p. 11).

Because of her motivation to make connections between science and the community, Ellen sees a fluidity in how scientific information travels from the lab to the classroom. She sees her role as a teacher as an extension of the role of the scientist in the lab. The researcher does not believe that this type of understanding concerning the role of a science teacher could exist without a very strong etiology for situating science socially. And this strong social-science emphasis has affected Ellen's teaching practices. She continued:

> We got a challenge here, how am I going to make it so Bobby Sue can understand this and we will change our procedure so we can get more results but it is another way of doing science. I think teaching is a science. We have our resources, we have our raw materials, we have a problem, but our hypothesis depends on the population that we sample. No, I don't see in the disciplines themselves any difference. Now how they present it is a different thing. I would have liked to see a little more of educational friendliness but I was surprised to see the level that I did see (Ellen, Interview 2, 2004, p. 11).

Here Ellen states that she sees herself as a scientist and the scientists at the biotechnology center as educators. She sees the role of teaching as a scientific endeavor. Her understanding of science as an open-ended investigation affected by the community makes Ellen's conceptualization of biotechnology, science and teaching different from the other participants. Other participants saw their role as teaching, separated from the role of scientist in the lab. They saw science as being a discrete body of knowledge that had less fluidity within the community.

She also mentions that there exists a level of unfriendliness between scientists and teachers. She remarked in an interview that she was pleased to see a much higher level of friendliness between the scientists at the biotechnology center and the teachers who attended the conference than she was expecting.

Ellen's Classroom Teaching

The researcher visited one of Ellen's general biology classes, which contained a heterogeneous mix both ethnically and socio-economically. There were both African-American and Hispanic students. Ellen's class also contained five girls and sixteen boys, including two black students. Some students dressed well, some did not. Some spoke using correct English, other did not. Ellen said that it was a "real mix." Some students were still eating breakfast they had bought in the cafeteria that morning.

Ellen had given the students a worksheet from the protocol that was provided by the center. She told the researcher that the vocabulary and reading were difficult for this class. Ellen went around and sounded out words like cytosine for students. She also helped students with understanding what they had read. It was apparent to the researcher that some students had not read the assignment before class.

Ellen gives the students board work (what she refers to as "bell work") to get started with DNA molecule and DNA replication topics. Since the kits arrived slightly off the teacher's schedule, most students at this school had not had very much prior knowledge into DNA molecular engineering, just applied genetics and the discoveries around the finding of DNA information. Ellen went around and checked for understanding of DNA replication and offered after-school tutoring in her room for those students who were still struggling.

Next Ellen passed out instructions and told the students that they were going to extract DNA from strawberries. One student said "That's awesome." Because she knew that the vocabulary would be problematic, she had them look up the word polyploidy in the back of the book. She spelled the word out for the students. The student began to read out definitions in unison. The researcher assumed that Ellen was also reviewing previously-learned material on cellular biology when she talked to students about where the DNA is in the cell. She reminded students that they would be working with strawberry cells, which were plant cells and had a cell wall. The teacher then asked the students; "How are we going to get past cell wall?" One student suggested that they mash it open, or cut it open. Ellen suggested that they would have to manipulate it somehow and isolate the DNA. She asked, "Do we always have to use scissors or knives?" Students answered; "No, we can use enzymes." She talked about what molecular parts make up cell walls and cell membranes. When she saw that students were not making a connection with the review material, Ellen continued, "Think about the dishes you wash. Why does soap clean? How does it do it?" She continued by telling students that soap breaks up the molecules by repelling the lipids. She said, "If you haven't washed your hair in five days, it gets greasy, so soap gets rid of it. That's how dish washing liquid works."

Ellen then continued with the protocol of the DNA extraction by explaining to the students that they were going to strain the strawberry mush and get a liquid including DNA and other material (like water) from large vacuoles inside of plant cells. She asked "What is something that doesn't mix with water?" One student said alcohol. She explained that because alcohol and water do not mix, adding cold ethanol causes a separation of the DNA as it gets close together and students would see a precipitate. She read the question along with the students from the lab protocol in the lab manual sent by the Biotechnology Center and students answered questions. Students suggested answers out loud and Ellen built on each answer:

Ellen: “What could we use this DNA for?

Students yelled the word “cloning.”

Ellen: Cloning, let’s see, do we use cloning for agriculture?

Students: Yes.

Ellen: How? How do we use DNA in agriculture?

One student: We can use genetic engineering, mixing it with another fruit.

Ellen carried on a great dialogue with students discussing possible uses for biotechnology. Ellen’s students seemed to recognize the uses of the biotechnology dialogue because she framed each of her questions in a manner that would be recognizable to her students. For example, she used agricultural influences to frame her questions on extraction of DNA from a strawberry.

Ellen showed the students where all the materials were and how to get the supplies. Students got a good yield of DNA from strawberries. They remarked about how “It is cool but somewhat gross.” All the students were on-task throughout the lab. As students filtered strawberry juice through the cheesecloth to extract cellular parts, Ellen continued to talk about the ethical implications of biotechnology. She mentioned agricultural uses of biotechnology as well as cloning. Students were then given a guided practice sheet on protein synthesis, which required students to code for specific proteins. This was not guided practice provided by the biotechnology center but developed by Ellen in order to help make the connection between what students just pulled out of the cell in their experiment and the process of protein synthesis that they went over in class in the past two days.

The next day the actual DNA electrophoresis lab was scheduled. Ellen handed out the instructions on how to do the pipetting. Students began to ask questions about the lab. They were currently taking a test and Ellen wanted them to be quiet. This made the activity a bit problematic because the students were visibly more interested in doing the lab and less interested in the test.

After the test, students were instructed on how to load a well, what the gel is made out of and what the dye is made of. Ellen had already pre-measured all materials so students needed only to load wells in the gels. Ellen showed them how to push the plunger down, release it while the point was still in fluid to suck up the fluid. Students wanted to do so immediately. Students were all on-task and wanted to complete the lab.

Ellen stated, “It is a slow trigger, not a quick one” The researcher finds this an interesting gun metaphor, one students seemed immediately to recognize. In a rural area where hunting is a favorite pastime of many students, this metaphor was familiar. Students loaded the gels very well. While students waited for the gels to run, students shared that some family members have bachelor’s degrees in chemistry and that they wanted to do this type of science too. Ellen had “down time” while they were waiting for the gels to complete, a time for students to share their own thoughts. The student discussion didn’t deal with practicing pipetting as much as it deals with the nature of science in general. Ellen said that “biotechnology is the career of the future. You need steady hands, so don’t do anything to make them unsteady.” One student said “This is real science.”

The next day, Ellen's classes analyzed their gels. Several groups had run several of the gels in the opposite direction. This is an easy mistake, one which the researcher has done more than once. This morning, several of her classes also needed to re-dye the gels since the bands were not clearly visible. She explained that the protocols for each scenario in the lab manual from the Biotechnology Center are different. Ellen explained how DNA is used in court cases. Ellen pointed to the researcher and said "Our forensic scientist [the researcher] says that even in the lab, they run gels backwards." The researcher is sure that scientists do not do this; however he shared with Ellen that he has made this error in his own classes before. However, all students were able to deduce who the criminal was by looking at the gels and comparing the bands. Each of the students responded extremely well during the observation and it seemed that the lab went very well, overall.

Several weeks before the kits arrived at Little Rock, Ellen taught an extension to a genetics lesson. In this lesson**,** Ellen had her students read a small passage about the sterilization of mentally retarded people in the state and how they were given monetary compensation for submitting to the procedure. She asked students to write one or two sentences supporting how they felt about that practice. She was eager to share them with the researcher.

Student 1: I feel bad for the people that had got sterilized, but wouldn't take money from taxes to give them

Student 2: You should just make an island for them.

Student 3: I think that is terrible and unfair.

Student 4: It makes me mad.

Student 5: I think we should use it. It would help control disease and it would increase our health care.

Student 6: I feel that eugenics is important because it doesn't let the people who are retarded have children.

Student 7: I think that retarded people and all those other people should have the choice of having a child or not.

Student 8: I wouldn't want a retarded baby because you will have to put him in a program and I want my child to have a good diploma.

Even with a small amount or prompting from an element in a lesson, students were able to identify and explore some very complex legal and ethical issues.

Post-Observational Interview: Ellen

In post-observational interview, Ellen stated that she was pleased with the way the lab went and how it fit into her curriculum. She began with a bio-informatics lesson where students briefly learned the steps scientists go through in order to produce a gel for analysis and how matching similar banding patterns could be used to discern identity. However, during several post-observational interviews, she seemed focused on the next unit she was teaching on evolution and did not seem to want to expand upon her answers. When asked about how she thought the students in her classes responded to the lab, she did begin a conversation about a difference she saw in the excitement of students who were from upper socioeconomic levels (and therefore in advanced classes) versus responses of those students who would be categorized as lower-socio-economic and enrolled in general classes. She explained, "Those who have [resources and prior experience] take it [lab experiences] for granted and I don't see the enthusiasm…they just go through the lab." She continues, "Those who have not, can't wait to do it, and I try to curb their excited behavior so they can do the lab." Of interest to the researcher is behavior that may cause a student not be able to participate in Ellen's class is classified very differently than in Francis's class. Where Francis looked at particular behaviors as being more socially-oriented, Ellen sees poor behavior as stemming from excitement about doing science in a way that may be foreign to a student. Ellen did say that if behavior could not be curbed, then students would not be able to participate in the lab.

Ellen also suggested that pigeonholing students into general or accelerated classes begins at an early age. She suggests that they are troubled students or students who have difficulty following directions and are directed into general classes. She did say that these students needed experience science in a kinesthetic manner: "If they can't see it, then how are they going to figure it out"?

Analysis of Ellen's Classroom Teaching

Ellen made a clear connection with both biotechnology and explicit ethical concepts as she introduced biotechnology into her classroom. She made simple and strong connections between molecular biology covered earlier in the school year and their connection with a real-world scientific investigation. And because Ellen presented a space for students to have a voice about bioethics, she allowed all students access to the lab, not just those who may have shared in similar sensibilities with her. In this way, all students gained participation from the lab.

Ellen also suggested poor classroom behavior could be a result of excitement rather than from a negative force. This was an interesting contrast with Francis's description of behavior. Although the researcher observed that both teachers would block access to the lab if classroom behavior was so disruptive that student or equipment safety was in question, Ellen seemed to frame behavior differently than Francis. Francis said in a post-interview that she thought that students who misbehaved in class and were denied access to the lab did so because they were not used to using equipment and doing labs. In contrast Ellen suggested in a post-interview that this type of pigeonholing occurs early on in grade school, noting that students who do not follow directions or those who have disruptive behavior tend to be grouped into lower level classes that do not gain access to lab experiences. Because of a lack of experience, these students do not gain the necessary lab behavior skills necessary to do labs later on in school, and therefore lack opportunities to to learn how to act during lab experiences. Francis framed discipline in some ways that support socioeconomic hierarchies (students whose behaviors are poor can be attributed to certain ways of social thinking and behaving), whereas Ellen framed discipline in a way that was less supportive of these hierarchies. She attributes poor classroom behavior, at least partially to lack of experiences in the past and not knowing how to curb excitement.

Chapter Seven: Analysis of Research

Research Question One: How Did Biotechnology Emerge in the State?

Based on scientist and classroom science teacher interests and initiatives in the emerging field of biotechnology, the researcher suggests that biotechnology emerged in a socially-constructed manner. Several classroom teachers, like Margaret and Bridgett who are leaders in the science education field, took an interest in biotechnology when introduced to it through the Advanced Placement Biology curriculum as well as on the university level. Scientists on the university level were eager to generate public interest in order to establish a facility for interdisciplinary research. Due to an interesting turn of events, teachers met scientists and developed an outreach educational program. Students from almost every area of the state were offered an opportunity to explore biotechnology practices in their classrooms with the help of the center's education program, as each year the center loans out thousands of dollars' worth of equipment to both public and private school systems.

Callahan (1962) and McClaren and Barton (2001) might see the emergence of the center's educational outreach program as a means to generate public interest and demand in order to develop an economic landscape. Without a landscape of interested members of the community who value biotechnology and want to learn about it, the center's existence would be improbable. However, a traditional and very hard economic definition of the biotechnology center explicitly as a business, like other biotechnology research facilities, may not clearly delineate the center and its role within the community.

In their interviews, all participants suggested that they were aware of some direct or indirect financial connection with the center and other businesses in the corporate sector. Some corporate interests do exist and seem to flow from the center. However, at least several of these connections are not as black-boxed as one would expect, considering artificial practices that connect two different entities like teachers and corporate stakeholders. The fact that the center has responded to teachers' interests by including a heavy emphasis on bioethics would suggest that there is a reciprocal exchange of ideas in how the center might position itself as far as the importance of use of biotechnology in the community.

In order to look at the biotechnology center as a stakeholder that emphasizes purely corporate goals, the center would have to present and categorize science and scientists with strict positivism and present the technology used with hard determinism and instrumentalism. In short, as Johansen (1991), Bowker and Star (1999), Lemke (2001), and Mackenzie & Wacjum (2000) would suggest, the biotechnology center would have to categorize science that was value-neutral, separate from any social implications, and reproducible in multiple places. This does not seem to be the case through this study, at least to some degree.

In its infancy, the center's protocol did not include much ethical information. This, coupled with the analysis of the documents that were available in the center for teachers, would suggest that biotechnology can be seen with strict positivism and determinism, which in turn would support any corporate goals that might be working through the center. However, when the researcher examined the presentations at the last several conferences and the abundance of ethical information in both the protocols and the kits, it may be safe to suggest that the scientists at the center see themselves in multiple ways regarding the science that they practice, and consciously put that side of research out into the public forum. Roth and Lawless (2002) and Glasson and Bentley (2000) would suggest that scientists view science with multiple epistemologies.

Traditionalists like Hurd (2002) might assert that the center, as a stakeholder, is attempting to become more transdisciplinary simply because scientists have to go about much more creative ways of securing funding. They may suggest that because the center depends on the community in order to buy biotechnological products or to enroll in biotechnology classes, it became necessary for the center to keep up with the needs of the teachers in order to maintain a steady clientele. By providing bioethical information publicly, the center is simply re-creating new reassembled identities in order to continue to support artificial connections between the teachers and itself (Callon, 1986). These connections, for example, might be one where the center can distribute bioethical information to teachers in order to keep teachers' identity stabile enough to continue a relationship with the center. However, in the very act of reconnecting with teachers and constantly developing new identities, the center is changing itself, through reinterpreting corporate goals and definitions of biotechnology.

The researcher suggests that this reconnecting with teachers (and ultimately, students) is the subtle interchange of ideas and thoughts that makes biotechnology, largely isolated from the community, as a socially-constructed measure. In fact, the researcher suggests that few entities like the biotechnology center could exist at all within the strictest view of corporate intentions. The center and the teachers sharing a space like the conference and sharing dialogue allows for a more democratic interpretation of biotechnology. It allows for scientists to define biotechnology in ways that are more situated within the community, and it allows for teachers to embrace a pragmatic empiricism while framing it within communal worldviews.

Like Jones' (2000) examination of Monsanto's failure to stabilize a definition of biotechnology without clear connection with the community in which it existed, the biotechnology center depends on teachers to elicit excitement about biotechnology in their classes and the community. Teachers bring a pragmatic realism about how that science is socially-constructed within the community. With the interplay of the center and teachers re-establishing flexible roles, biotechnology can be defined in a way that allows the center to exist. This is an interesting phenomenon, because when either side does not immerse itself reflectively in the other's worldview, biotechnology and the community become two separate spheres again. For example, although Francis embraced the equipment from the center, her teaching practices did not incorporate the bioethical emphasis of the conference; therefore, her conceptualization of biotechnology became mostly positivistic and empirical. Francis's teaching practices were then forced to incorporate science as a positivistic tool in order to obtain her educational goals. Clarisse also embraced the technology, but did not emphasize the ethical issues in her chemistry class. And because of the separation between the economic and scientific curriculum that her students receive, Clarisse's teaching practices also focused on strict positivism.

The communal sphere that existed during the conference for Clarisse and Francis did not ultimately shape their teaching practices. The two spheres, science and the community, remained largely separate. And although it became evident through interviews that both teachers were aware of the communal connections that emerged during the biotechnology conference, such connections were lost once the teachers entered the classroom.

Where both the communal and the empirical spheres of science traveled from the conference to the classroom was in the case of Ellen. She not only reflected on what the conference meant to her personally as a teacher learning new content, but she also pondered on how such rich duality from both spheres could transfer into her classroom and remain meaningful to her students.

What becomes evident are the linguistic and cultural steps that Latour (1999) would define as realistic relativism. Here linguistic steps are taken between science and members of the community through an intersection like biotechnology. The fact that the center is part of a larger scientific and social community, and therefore constantly attempts to reinterpret roles of teachers, would advocate that these roles are morphing due to the constant competing forces exerted by scientists and community. Not having roles being clearly or statically defined also suggests a certain mobility of information that is certainly not representative of an entity that is in control of assemblages, or of one that has successfully made artificial connections. The researcher is reminded of the definition of biotechnology as “the intergrated science of the 21st century” by one of the conference lecturers. Here, the second speaker at the conference was remarking about how flexible the science actually is.

Dewey (1916/1966) suggests that democratic ideals include more shared points of interest among members of the community. The fact that teachers asked for more bioethical information and the center provided it suggests that the center could be seen as a democratic space as it responded to teachers’ needs and recognizing and sharing leadership with those teachers who use the kits. Certainly Dewey and Latour would suggest that science is embedded in some sense of realism and that members of the community want their children to be schooled in this sense of scientific realism. The center provides a forum where scientists, teachers and other members of the community are encouraged to exchange ideas and forge more points of shared interest, which also implies that the resulting conceptualizations would contain very few linguistic steps between scientists and teacher.

If there exists a spectrum where a space including free exchange of ideas is communal on one side and pure corporate or global interest lies on the other, where would the center be? The researcher would suggest that it lies in all places on the spectrum simultaneously. As Nespor (1988) would suggest, the identities of members of the community do not remain static for very long. Their connections with other people and entities in the world continue to change them. What does seem to remain somewhat static would be the products by the center that are produced in the biotechnology field, and the written materials describing or advertising them. In stark contrast to the socially-constructed lectures and discussion with scientists in workshops were the material resources like the pamphlets from the Department of Energy and others. These documents were much more successful in remaining static in their ideas and definitions of biotechnology.

As far as interpersonal connections, linguistic steps, and exchange of ideas, the center does seem to be much more socially-constructed than the traditional corporate educational research would suggest. The role of public opinion seems to play a far more important role in whether the corporate goals of a stakeholder become naturalized or not.

As Jones' (2000) Monsanto research implies, the public ultimately determined how successful the company would be in naturalizing a definition of biotechnology that would support corporate goals. What the researcher saw was the center acting as a hybridized node with interests, both corporate and social, running through it within a geo-socio-corporate network. Public opinion and interest were the motivating factors that generated the interchange of ideas.

Researchers like Brantlinger (2003) and Kincheloe (1999) remind us that the public tends to believe that healthier economic markets will improve social conditions. However, this is not necessarily the case as teachers in this state conceptualize biotechnology. With very little financial or "sweat equity," teachers can obtain costly equipment to complete complex and interesting "cutting edge" science by utilizing resources from the biotechnology center. The actual road to these resources plays a much smaller part in how biotechnology is conceptualized in the classroom than originally thought. Issues of teacher economic identity and public perception play a much larger role.

Research Question Two: How do Biotechnology Resources and Connections with these Resources affect Classroom Teaching Practices?

The researcher will begin to explore to analyze how biotechnology resources affect teaching practices by looking at both the private and rural school. Clarisse and Francis are examples of teachers who represent a more corporate conceptualization of biotechnology, while Ellen's conceptualization would be representative of communal education.

*Clarisse and Francis: corporate science education***.** Because of the very act of privatization, one would expect to see a global perspective of science education at Granite High School, and indeed, that is what the research would suggest. Clarisse's classroom activities revealed a clear and distinct separation between the practice of biotechnology and explicit ethical or social discussion surrounding it. Any economics discussion that may have taken place with students was done separately in the economics class offered by an endowment. Clarisse stated that any socially responsible dialogue that was being discussed by her students in the economics classes would be how to spend money wisely that they earned from fundraisers on materials. There was no sign that any ethical conversations dealing with the economic or corporate nature of biotechnology occurred. This would imply that both the biotechnology information covered in Clarisse's class, as well as the economic information in the economics class, would be anchored in strict positivism and determinism. Because Clarisse suggested during an interview (and in the class) that she wanted to teach skills to her students that centered around successful percent yield implies that she educated students in a way that emphasizes corporate or global interests. By emphasizing reproducible science that is void of any social implications, students will get the idea that science is value-neutral and can be used in multiple places with similar results. It now becomes an economic matter of a community's ability to afford these practices; as for biotechnology, the cost of schools purchasing their own equipment is very high. Because this view does not take into consideration the personal capital, or "primary legitimate knowledge" (Jenkins, 1992, 85) of students, it emphasizes economic capital (Davis, 2001) over scientific practices like biotechnology because it supports a free market economy and corporate goals (Davis, 2000).

Similarly, Francis at Little Rock Public School also taught biotechnology lessons with strict positivism and determinism. She made no noticeable connection for the students between the scientific practice of biotechnology and its social implications. In fact, Francis was given many opportunities by her students through dialogue and questions to approach the issue in class and did not. Students at Little Rock do not get any formal economic training as students at Granite do. Aikenhead (2001) and Costa (1995) would suggest, the way these teachers designed curriculum can often leave students behind who struggle with comprehending scientific practice. This type of instructional design can set up barriers which marginalized students cannot overcome.

Certainly border crossing research like Aikendhead's is vital to understanding how science lessons that do not make explicit connections to any social implication create challenges for students. However, the researcher saw very few border crossing issues at Granite High School. All students there seemed fully to understand the material, participate well in the lab. And although border crossing issues most certainly existed in Francis's classes, they did not surface in the short time that the researcher was present in the class. There were more phenomena emerging in these two spaces than not addressing social issues connected with biotechnology that are equally as interesting, ranging from self-promotion to curriculum itself. For example, Francis was using the introduction of biotechnology concepts into her curriculum in order to establish a clientele for an Advanced Placement Biology class as well as promoting her own classroom abilities to administrators. This could only be done if she treated biotechnology with strict positivism, and began to categorize students according whether students would participate in the lab and to what extent.

Brantlinger (2005) suggests that we teach and exist in classroom settings in ways that mimic our own economic experiences. Davis (2001) would agree, since she sees that students' worldviews are linked to personal capital, which in turn is supported by other forms of capital, such as economic. She believes that students can be addressed in three categories based on socio-economic perception of the teacher, which in many ways are similar to Aikenhead's and Costas'. The researcher believes that this was also occurring in both Clarisse's and Francis' classrooms. In the case of Clarisse's classroom, her student body consisted of upper level socio-economic students who were eager to learn and who, as the school's mission statement suggests, are to be prepared to go to a strong college or university. These were students whose worldviews must certainly have included prior knowledge about biotechnology, as Clarisse suggested during one of her interviews. If Clarisse constructs biotechnology lessons that are void of any social implications of biotechnology, this sends out a strong message that she is teaching this type of science in a way that promotes reproducibility of biotechnology practices, emphasizing forms of capital that can be acquired. This would support any global or corporate goals of economic stakeholders in that she is training students who would most likely graduate and go on to universities and future employers with skills necessary to do this type of science. By not making overt connections with society, she is emphasizing a lesson that promotes a type of learning that supports a free market economy.

By not teaching the societal or ethical implications of biotechnology to her classes, Clarisse is explicitly supporting the existence of a three-tiered participatory category in the community. Like Brantlinger (2003), she implied that her students neatly assimilated into the "Already There" category. For students who do not share the same social capital, two outcomes emerge. Students will either aspire to border cross and would be considered "Upward Strivers" or students will dismiss the information as being irrelevant and would be considered "In-the-Middle." This emphasizes an economic hierarchy where "Already There" students have all resources, access to full participation, and ultimately the power to distribute access and resources in the future.

Francis's case is slightly different. Certainly her students would not be considered "Already There" students, since most of them are not socio-economically privileged. However, Francis sees students in her classes through this same hierarchal system. Because their classroom behavior does not match her behaviors, Francis feels students are not motivated in biology. Students should act as she does or their actions should be within a spectrum of behaviors that she deems as appropriate. It was observed when students' behavior did not meet her expectations, she simply removed them from access to the scientific practice. Interestingly, the students who did not experience any participation in Francis' class were those she deemed to be lower socio-economically. By referring to them as "rednecks" and "loud" black girls, she categorizes them as "In the Middle" and makes a distinction from those that do behave as she does or "Upward Striving" students.

Teaching in this exclusive manner supports a social class hierarchy that sets up barriers for students and marginalizes them in much the same way that not making the science meaningful enough for students to scaffold new information to what they already know does in border crossing. It limits the personal capital of the students by limiting their access to full participation. This, in turn, will limit their economic capital (Davis, 2001) because it blocks students' abilities to go on and store this information as symbolic capital if they continue to live in a community that views science as positivistic. It also blocks students from having a chance to work in the field of biotechnology or possibly being in a position where they could legislate it. This type of curriculum view also emphasizes forms of capital that would continue to support this hierarchy. "Already There" students (Brantlinger, 2003) would have most economic capital because they would have border crossed more successfully and would have had access to full participation in the lab (Aikenhead, 2001). By presenting biotechnology in the way she did, teaching pedagogies like Francis's deny social capital to the "Upward Striving" and "In the Middle" students by conceptualizing biotechnology in a way that disconnects that practice from any social ramification or identity.

The researcher has noticed over the years that most of these biotechnology labs are completed in upper level biology classes such as Advanced Placement classes or honors biology classes. He now agrees with the concept that many teachers teach with this idea of economic stratification that would result in mostly "Already There" students gaining access to lab experiences. Once they gain access and understand the knowledge, it is the "Already There" and the "Upwardly Striving" students who will grow up and are able to have a voice in the community about how to situate biotechnology socially. More than likely, "In-the-Middle" students will not have a voice in how it is socially constructed. As Lacan's (1982) research would suggest, domination of one group always results in the subordination of another. Brantlinger (2003) also suggests that there always must be a subordinate group in order for there to be a dominant one. Ensuring the

"Already There" students in their classes received social and economic capital, Francis and Clarisse marginalized those "Upwardly Striving and "In the Middle" students (who did not share the same worldview, social capital or positivistic view of science) into a subordinate group. These students did not have any access points on which to scaffold any content (Roth, 1995) and ultimately did not have success in the lab. In this study, all the students who fit into the subordinate group were rural, "In the Middle," or lower socio-economically.

Francis is an "Upward Striver" herself in a way. She and Little Rock High School had other reasons for bringing biotechnology to the school than simply to expose her students. She was very forthright in her first interview in saying that it was her intention to bring biotechnology to her school in order to generate administrator interest in incorporating an Advanced Placement Biology class to the curriculum. Both she and Ellen stated that they thought some student interest might already exist, but since it was an expensive class to teach, there had not been any administrator interest as of yet. By seeing her class actually doing one of the labs that was included in the Advanced Placement Biology curriculum, she thought administrators would reconsider their position.

Francis was also very explicit in discussing how she thought administrators would view her as being more knowledgeable if they could see her incorporating technology in her class. By viewing science in a positivistic way, Francis is supporting the idea that science is a practice full of crystallized truths and one that does not change. This promotes an idea that one's capital in learning science is gained by practicing it through a rigid series of standards (Davis, 2001; Lave & Wenger, 1991). This lends symbolic capital to both science and technology. Francis uses this extra symbolic capital to increase her professional capital with her employer. If she were to conceptualize biotechnology in a way that was not positivistic and incorporated an understanding that the community also plays a role in the practice of it, this type of capital would be greatly lessened.

The use of biotechnology to legitimize a class that will most likely be filled with "Already There" students and assuming that because she is using technology in her classroom (and somehow shares some form of power) also suggests that Francis is using biotechnology with strict positivism and determinism. To assume that technology holds some form of power is to agree with the idea that it is separate from society and that it is value-neutral. To assume that it holds power suggests that she sees the field of science as reproducible and that anyone who holds relationship with it will in some way gain powerful status within the community.

In both situations, Clarisse at Granite and Francis at Little Rock, there are clear signs that the ways these teachers were conceptualizing biotechnology were supportive to what the researcher would consider to be global economic education. They both taught in ways that supported strict positivism, hard determinism and also used a socio-economic hierarchy system to classify students, determining who would have access to the scientific practice and who would not. Clarrise and Francis brought elements into the classroom that strengthened the perception that biotechnology is reproducible and can be used to solve global economic problems through a free market economy, which Hughs (2000) would consider gatekeeping.

Neither teacher made explicit connections with any social or ethical meaning that students in their class would be able to use to scaffold new information onto and therefore relied strictly on previous academic work. In the case of the private school, this was not as much of a problem because most students were "Already There," not only economically but also had been exposed to critical thinking information in the past that made them ready to work with new information. In the case of Francis, this would have been a much bigger problem. Her students were much more academically and socially diverse than the ones at Granite. Therefore, the readiness of Francis' students to understand new material like biotechnology concepts was much more unlikely.

Both participants stated that administrators and parents favored teachers who went to conferences and brought back new ideas to their classes. Francis was clear that her administrators looked at science as a commodity that could be bargained for or purchased. As she brought new materials into the school, the perception of her worth rose in the eyes of her employers. This view of science as a commodity also supports a global perspective of biotechnology. A global perspective would view biotechnology as reproducible and static enough to move from one space to another, fully intact. Thinking this, it is a simple step to seeing biotechnology as a type of knowledge that can be bought and sold.

As Francis uses biotechnology in her classroom to elicit interest in an Advanced Placement Biology curriculum, this only goes to strengthen the idea that knowledge is power, and the more knowledge that one can acquire, the more powerful and competent a school system is. It also makes the Advanced Placement curriculum materials look more powerful, which in turn supports the commoditization of biology and thus a global perspective of biology.

In a post-observational visit and informal interview with Francis, she told the researcher that an Advanced Placement Biology class had been scheduled for the next school year. However, Gail, the new teacher who had forensic experience, was asked to teach it, much to Francis's disappointment. Francis was asked to take on additional responsibilities with more honors biology classes.

Ellen's class: communal science education. Ellen's classes at Little Rock are the exception to the study. The way that Ellen thought about biotechnology and its connections with society, the way she developed lessons that explicitly discussed social or ethical implications of biotechnology in their communication, and the connections that they made with her students made her conceptualization of biotechnology much more communal in nature.

Communal science education tends to be more democratic in nature and sees science as being post-positivistic, meaning that there is some truth to science but that truth is connected to realistic relativism (Latour, 1999). In many ways, Ellen's teaching and the way she conceptualized biotechnology supported elements that are similar to this view. For example**,** Ellen spoke in a very egalitarian manner in her pre-observational interviews. She saw explicit connections between biotechnology and her community, as she saw a need for her students to understand not only the molecular concepts associated with biotechnology but also ethical and social implications. She saw the center as a useful resource that she would continue to go to informally for more information. She did not have an agenda to exploit the lessons as a means to a more powerful teaching identity, nor did she see her students in strict socio-economic categories, as did Francis.

In the classroom, Ellen engaged her students in explicit dialogue. She let all students (regardless of behavior or academic motivation) participate, and prepared her students in complex ethical issues like eugenics before the kits arrived. Because Francis's classes were the first classes to use the kits and Ellen's were second, Ellen did not enjoy the same type of recognition in the school as Francis did, but she did not seem disappointed by this.

In many ways Ellen is a daughter of the county where she teaches and therefore most likely approaches teaching pedagogy in a more communal way. She gave every student many entry points in which to enter the conversation and understand the material. In this way, she was very successful in border crossing pedagogies (Aikenhead, 2001) for her students. She personally understood biotechnology to be a socially-constructed scientific practice and presented it that way to students. There were no visible signs that she saw her students via socio-economic stratification or hierarchy (Brantlinger, 2003). Very little that she talked about in class or to the researcher suggested that she thought of biotechnology with strict positivism or determinism (Johansen, 1991). She saw the scientific practice of biotechnology as socially-constructed and very flexible (Lave & Wegner, 1991).

Another interesting feature of Ellen's teaching identity that neither Francis nor Clarisse demonstrated was a strong connection between what she was doing as a teacher and what members of the biotechnology center were doing as science. In fact, she was the only participant in the whole study that considered herself a scientist and considered members of the biotechnology center as being teachers. To Ellen, there was a very natural flow of ideas from the center both to her and her students. She referred to some of her students as “scientists” throughout the observation. This reflects a very deep appreciation and understanding for how knowledge is created and moves from one space to another (Glasson and Bentley, 2000; Latour, 1999; Lave & Wegner, 1991; Latour and Woolgar, 1979). She sees science as being a socially-constructed, human endeavor. For her, progress along the linguistic spectrum between the lab and the classroom moved fluidly back and forth.

Her work in the class and with her students makes Ellen’s teaching supportive of a more communal science education because she makes strong connections with society, supports a more post-positivistic view of biotechnology, and sees technology as being softly determined. She willingly developed a conceptualization of biotechnology that shared personal capital with the students. None of these elements would support the separation of science from the community, the commoditization of biotechnology or other corporate goals.

Of particular interest to the researcher, was that, when answering questions during her interviews, Ellen seemed very ambivalent about how biotechnology was socially situated. She never articulated a clear sense of understanding that complex issues surrounding biotechnology require complex epistemologies by the teachers who conceptualize them. She continued to feel uneasy about her thoughts but remained steadfast that she would approach biotechnology by emphasizing real world connections.

Research Question Three: How do Perceived Forces within the Community such as Economic and Public Perception affect the Image of Biotechnology?

Much of the perception of biotechnology is not supported by the biotechnology center but much more by the perception of biotechnology in the community. Again, referring back to Actor Network Theory described previously in this study, forces attempt to stabilize objects and ideas in the community in order to control them (Hughs, 2000; Callon, 1986). By creating for the public a stabilized definition of biotechnology, a stakeholder can exercise social control. By this the researcher means that mobilizing newly-formed relationships can allow stakeholders to move these relationships from one place to another. However, this is a relatively static understanding of this concept and one that is not suitable for the center. As mentioned earlier, although the center may have a vested interest in a definition for biotechnology that remains intact from the lab to the classroom, scientists interviewed and the conference emphasis suggests that areas where teachers and scientists can come together is where Latour's linguistic steps develop and less of these steps are necessary to develop a common definition of what biotechnology is. From the researcher's experience with the center, that definition is flexible and must remain that way if the center wants to continue a connection with teachers. Before this research began, the researcher believed that there would be evidence that the biotechnology center would afford some control to science teachers who utilize its resources. Much to the researcher's surprise, the biotechnology center does not play nearly as an important role in the stabilization of a definition of biotechnology as do the public and economic forces found in the community in which the participants taught.

Granite High School is located near the state capital. It is only a few hours from a large city in the nation where medical and genetic research help to define the economics of the community. Students who attended Granite High School are those students in the state with many advantages, such as access to the life experiences that would widen worldviews greatly and grant social capital within the community. These students are familiar with biotechnology as it appears in their community. They know parents of students (or even their own parents) who work in this line of research. They have more opportunity to read newspapers or be aware of biotechnology as it relates to their way of life. Therefore, it is this socio-economic network that culminates in how the public in the Granite High School community familiarize themselves with biotechnology and shape its industrial image. Teachers who teach science at Granite are much more likely to have heard of this type of science. Even if they have not had the opportunity to have gone through a biotechnology lab in their coursework in college, they would have more of an opportunity to explore biotechnology through costly workshops and conferences.

In Little Rock High School, there is another source that plays an important role in how members of the community conceptualize biotechnology or would determine the industrial image of biotechnology. There are no visible signs of biotechnology in the workforce in Little Rock. There are no research facilities in Little Rock, and there are very few jobs in the area that would utilize this type of science – only the law enforcement and criminal investigation sector of the business world. The social force that plays an important role in how people in Little Rock become familiar with biotechnology is the media.

Adrianne, the representative of the media in this study, suggested that most people who live in rural areas of the state where there are no visible signs of biotechnology in the community will familiarize themselves with biotechnology through television shows like *Crime Scene Investigation* or *CSI*. Looking back through classroom observations, there was very little mention of this television show at Granite High School, but the student and teacher dialogue everywhere at Little Rock was littered with that comparison throughout. Adrianne suggests that the way that biotechnology is represented in this series, as well as many of the television dramatizations of criminal forensic investigative work, is quite simplified. By this she means that the outcomes are simplistic. The media represents biotechnology as reproducible, value-neutral and in Adrianne's words, "black and white." They do not make explicit connections with bioethics or social implications. Such outcomes can be considered positivistic, deterministic and support a global perspective of science. Members of the community who watch these shows develop a positivistic sense regarding this biotechnology. A positivistic view of science supports the fact that certain types of knowledge carry with them a certain amount of power. This power results from gaining access to certain knowledge and treating that knowledge as though it is reproducible and can ultimately be commoditized, which in turn supports a free market economy. Now members of the community view science, in this case biotechnology, as goods and services that can be obtained through economic or academic hurdles that result in a lack of thought about the human capital involved in the practice as it exists in the community.

As the researcher traveled to both the private and rural schools, he observed the outward appearance of the communities and businesses around both schools. In geographical areas of the state where biotechnology research and industry have already been established, like that of Granite High School, the standard of living was noticeably higher. Homes and lawns were well-manicured, street signs were decorative, roads were in good condition, and businesses were abundant. For example, there were corporate headquarters, doctors' offices and research facilities sandwiched in between strip malls, gas stations and convenience stores. This seemed to be a busy area full of economic growth and promise. People with more economic security and resources could afford to live there. The entire city did not take on this feeling of economic wealth, however. In fact, only a few miles away, still within the city limits, there were homes and neighborhoods that fell very short of being economically promising. These were neighborhoods with fewer economically active businesses, more storefront properties with limited growth potential; homes seemed older and in disrepair, streets were not in good shape, street signs and street lights were older; this is what one might expect in a city with limited resources.

Students who attended Granite High School were students whose parents lived in affluent geographical areas. These students would first have more resources at their disposal because of their parents' wealth. Secondly, these students were being taught a view of biotechnology that was similar to the view of the residents of this wealthy neighborhood. This view was one where biotechnology was separate from society, positivistic and deterministic in nature, one that would allow biotechnology to support a free market economy. Students who have the most abundant resources are more likely to live in more affluent areas where biotechnology research and industry centers exist.

These centers provide the tenets by which the members of the community conceptualize science.

These students are also the ones who are given the most points of access into the fullest participation in biotechnology practices. They will be more likely then to practice this type of science when they move out into the community and into the job force. They will be the students who will have more advantages to get better and more powerful jobs upon exiting universities, just as they are more likely to be able to control such biotechnology practices in communities in the future. By supporting a positivistic view of biotechnology, Granite High School can ensure that its students can have every opportunity to control the perception of biotechnology in the future, either by working with it for a living, or legislating it through the government.

The geographical area around Little Rock High School lies in stark contrast to that of Granite High School. There are businesses around the school, but these consist of convenience stores, gas stations, grocery stores, funeral homes or lower-paying facilities. There are no large research facilities or industries nearby and only one very small college fifteen miles away. Most of the area still consists of agricultural land and accompanying businesses. There were no visible signs of biotechnology available to students or the public in neighborhoods near Little Rock. The neighborhoods around the school were very large and consisted of small homes spaced out amid large areas of farm land. The predominant view of biotechnology has been shaped by the predominant medium, television. Certainly most of the people, students or teachers, who spoke to the researcher mention *CSI*. This television show is aired on one of the three major networks, the significant media source in the community. Students and their families at

Little Rock may not have financial resources to pay for cable television, which airs show with more realistic and humanistic perspectives of biotechnology like *Cold Case Files* and others. The view that most students had of biotechnology was one where science was separated from society, simplistic, and reproducible.

This view is not communal and does not best fit the students' science education at Little Rock. It will continue to support a socioeconomic hierarchy, where students who support a positivistic view of science will have access to full participation, and those who do not share this view will be marginalized. Because of the economic disparity at Little Rock High School, the public perception of biotechnology remains positivistic, which in turn will largely determine how biotechnology resources provided by the center will be conceptualized.

The students who attend Little Rock High School and live in more affluent areas are more likely to come in contact with geographical areas where biotechnology research is represented. They may also be students who have had resources that allowed them to be exposed to biotechnology before. These students will most likely share the view of biotechnology as being positivistic, because they will find it easier to border cross in classrooms, gain academic merit, and be perceived by faculty as either "Already There" students or "Upward Striving" students. They will receive more access to full participation and be more likely to either take part in biotechnology employment later on in their careers or be in positions where they can control its legislation. The student hierarchy continues to raise one socio-economic level of students while marginalizing those of lower socio-economic status. Those students who did not share in the same globalized view as Francis or the public were not granted access for participation. They would, therefore, not be placed in positions where they could have a voice in how biotechnology was developed or legislated in their community in the future. They would always be forced to interpret and socially situate biotechnology according to the "Already There" mentality of those with more social capital.

This type of connection between biotechnology and the community is one where, in many cases, artificial associations must be constantly forged and members' identities must be tightly controlled (Callon, 1986). Stakeholders must efficiently develop and infiltrate the ethos of community members with a static definition of biotechnology in order for such assemblages to be successful. If this perspective is tightly controlled, then stakeholders can guide how the community will situate biotechnology, which usually marginalizes the already disenfranchised. In the case of biotechnology in Francis' room at Little Rock, students who adopt a similar definition of biotechnology practices as presented by the media shared a similar definition with Francis and probably have an easier time getting through the laboratory experience successfully. Those students who did not share a similar definition of biotechnology and could not find common points of shared interest (Dewey, 1916/1966) found obstacles that would not allow them easily to assimilate information (Aikenhead, 2001). Also, these students who did not share a similar definition of biotechnology were those students who did not share an economic worldview similar to the teacher and therefore had a much more difficult time assimilating to the same socioeconomic goals that Francis had for her students (Brantlinger, 2003).

In both Granite and Little Rock High Schools, the positivistic view of science supports a free market economy; economic stakeholders will benefit directly by forging artificial assemblages and controlling these communities' view of biotechnology. The possible exception to this study was Ellen's classroom at Little Rock. In her classroom, Ellen took a very post-positivistic stance toward biotechnology. She did not separate biotechnology from society, and in fact, emphasized social and ethical implications. She had her students write their own feelings about biotechnology as an integral part of her lessons. She also connected the social implications to the economic landscape of the county in which she teaches. She made very human connections between the students and agriculture, hunting and farming. She spoke of democracy in her classroom lessons and acceptance of other students' worldviews. She did not seem concerned that she did not receive the same attention that Francis did when introducing the lab into her classroom; from subsequent informal interviews, she also did not seem upset that Gail was chosen to teach the Advanced Placement Biology class. Her pedagogies were complex, yet Ellen was able to make important connections with the material that ran counter to the curriculum and supported a more communal view of biotechnology.

This communal view of Ellen's allowed all of her students to have access to full participation, regardless of socioeconomic background. In this way, she placed her students in positions where they could have a voice in how biotechnology is developed and legislated in the state in the future. Her teaching can be considered communal because Ellen's practices do not fully support the global or corporate goals of economic stakeholders. By raising up all socioeconomic levels of students, Ellen's conceptualization of biotechnology can be seen as quite emancipatory. She made every effort to share forms of capital, both social and economic, and not use the curriculum to support traditional symbolic science capital or corporate intentions. She included students' worldviews, encouraged shared points of interest for students' access to participation, and asked for an interchange of ideas from her students. This interchange placed students in a better position to gain capital in the future.

Implications for Future Research

Complication of time. The researcher is aware that the amount of time that the kits were in the schools examined was very brief. A strong ethnography would include a much longer period of observation at both the private and public schools in order better to determine the flavor of the communities. Because the researcher is suggesting that forces that stabilize a definition of biotechnology seem to be strongest within the community in which the schools were located, more time spent in this communities could only enhance the overall understanding of how these forces work.

Stratification of curriculum in relation to social hierarchies. The researcher suggests that in places where biotechnology did not travel from the lab into the classroom with dualistic richness, many times students did not enjoy full participation in lab experiences. When science is separated from its social counterpart, it becomes a commodity that can be bargained for with social capital. In many cases, certain socio-economic levels of students did not have sufficient social capital, to gain access to the lab experience and therefore did not achieve full participation. These students were seen by their instructors as insufficient, lacking social capital and had either to border cross or assimilate the teacher's socio-economic or academic identity. These students were also grouped in similar general level classes. Future research into the enrollment philosophies of schools like the ones in this study could shed insight on how socio-economic discrimination becomes formalized in an educational setting.

Latour's (1999) linguistic steps are also a fertile area of research as new forms of science emerge from the lab and make their way into the classroom. Through his history with public education and graduate school, the researcher believes there are linguistic steps that members of a community ignore in order to continue some sense of reality within their own lives. This includes steps which reflected a positivistic stance. Such an interpretation of knowledge is constructed early in a member's ethos and is supported by varying degrees throughout life. Just as students look for common points of interest on which to scaffold new information, the researcher believes that people acquire knowledge through points of interest as well. The researcher also believes that we, as a community, are taught to overlook such steps to sustain a sense of reality in relation to that knowledge. Regardless of how much educational theory develops on the college level and how much instructional pedagogy is emphasized in public education, some major disconnects still exist that prevent members of the educational community from merging theory and practice. Future research may include what community-driven forces sustain this bias.

Curricula that tend to focus on strict scientific empiricism such as the Advanced Placement and SOL should be acknowledged as one element of a very complex scientific field. These curricula should be investigated for their emphasis on strict positivism as well as promoting socio-economic bias among students, teachers and schools

In looking at successful student outcomes Carter (2005), Brantlinger (2003), and Barton (2000) suggest that we as science educators look "upward" within our research. No longer are we looking at the disenfranchised student sufficiently understand how scientific concepts become shaped by forces that continue to subjugate them. By focusing our attention on those students who are able in some way to border cross successfully, or can assimilate correct behavior in order to gain full access to biotechnology, science researchers can better identify what actions by students contribute to their success. This information would go a long way in helping educators deconstruct their own biases as well as questioning the classroom teacher's role as censor of or conduit to knowledge and information.

Recommendations

Corporate education is largely thought of by many science educators as being a gateway to global intentions. However, it does not have to be. Areas like the biotechnology center are fertile grounds for providing spaces for both teachers and scientists to meet, gain mutual respect and share ideas. Such a space would help define a mutually inclusive definition for scientific practices that are just emerging from labs. It would limit linguistic steps in redefining such practices for the general public. It is their connection with the public, when actions and ideas are shared, that make such spaces rare within a corporate or communal sphere. Although such places like the center will always remain close to a corporate sphere for their own existence, allowing for such a space can also provide scientists a place to share their own worldviews with the community. What can emerge is a pragmatic economic realism that certainly remains corporate-driven but not always full of global intentions.

Biotechnology education is quickly becoming conceptualized by many people within the community. To keep such scientific practices hybridized, democratic and realistic, no longer are definitions like corporate education appropriate. Theoretical frameworks develop for such terms and soon what emerge are dichotomies of thoughts, forcing educators to develop their own epistemologies according to one or the other. Biotechnology needs to remain flexibly planted in both worlds and should be researched, spoken and practiced with the activities and vernacular of both spheres. Current educational curricula like Advanced Placement Biology and state mandated tests should elicit thinking from students that treats science in both the empirical and cultural worlds. To view biotechnology in any other way ultimately makes this scientific practice static, on either end of the theoretical spectrum and does not reflect the pure duplicitous nature of the science.

To many, a communal perspective is counter to the message that educational administration, recent educational reforms and the community at large is sending to teachers. Therefore, most likely, teachers attempting to develop individual teaching epistemologies will lack support and ultimately fall back to teaching identities that are less likely to conflict with mainstream educational thinking. It is important for the leadership of both the scientific and educational community to make more visible that new forms of science will undoubtedly be more contrary to popular perception. There are no supportive connections in place in either the public or private school which would continue to help teachers with diverse classes or curricula emphasize the hybridization of science.

Another issue that arose in this study was the fact that Francis was a new teacher. The likelihood of her being able to think and reflect appropriately about this complex nature of biotechnology along with the difficult daily routine of a new or beginning teacher seem remote. Although Ellen was also a new teacher to the school, she was quite a bit older than Francis and had a great deal of life experience as well as experience with science from her daily life. The expectation of having pre-service or new teachers be able to have such a broad worldview like Ellen's may be too high. In this case it is essential that the teaching profession support new and beginning teachers by sending them out into the community to see science in action. They should make every effort to experience biotechnology from different perspective, like biotechnology centers, or hospitals, research institutions and others. If these places do not exist within the community, it is important for new teachers to find these areas in neighboring communities through connections with other teachers in professional organizations.

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Appendix A

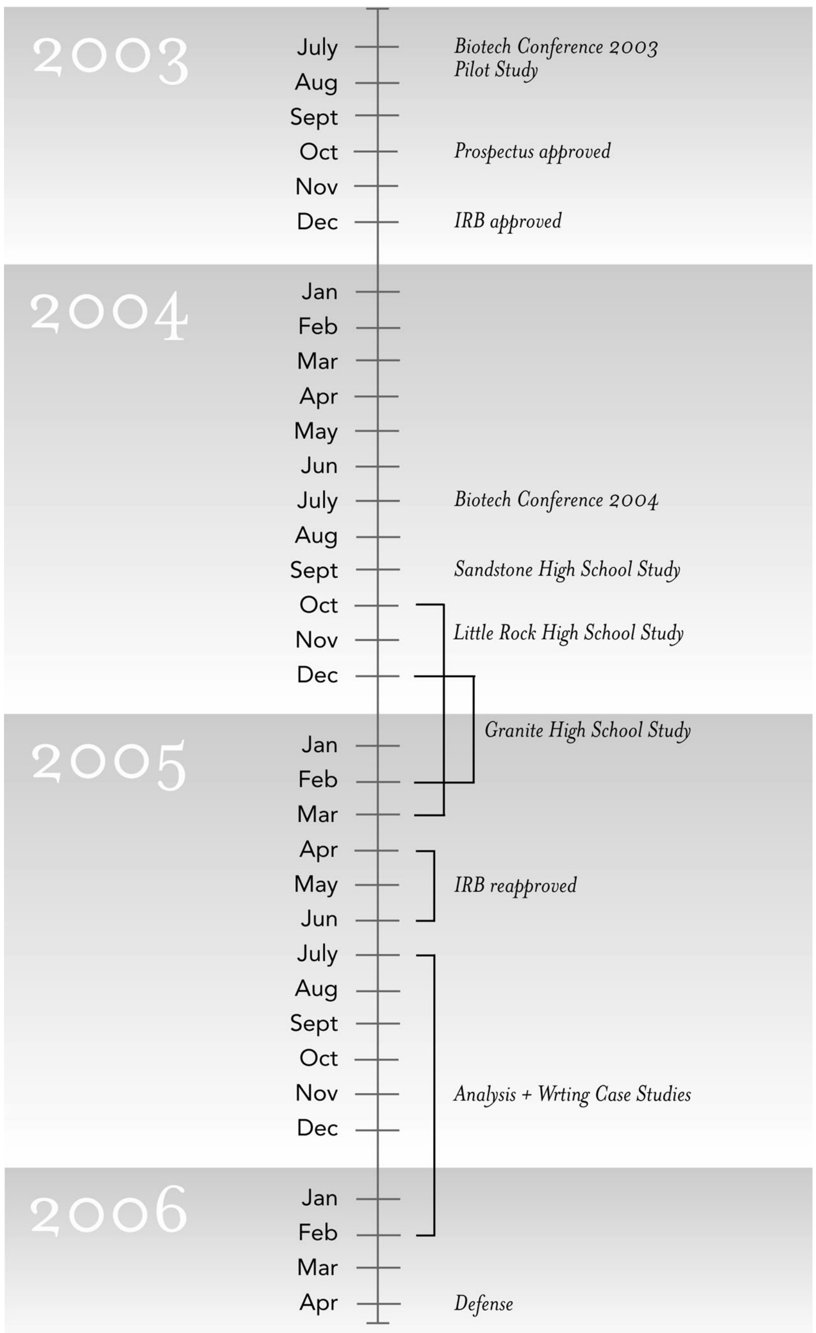
Scientists Interview Protocol

Virginia Polytechnic Institute and State University
Fralin Interview Schedule

1. Tell me how you came to Fralin?
2. What roles do you play here in Fralin?
3. Describe for me how scientific research happens at Fralin?
4. How representative is the scientific information that emerges here at Fralin of your beliefs about science?
5. What forms of communication with teachers do you use?
6. How do you determine what types of biotechnology to emphasize in the kits?
7. How do teachers affect how the kits evolve at Fralin?
8. How do you make science accessible for teachers who do not have previous experience with biotechnology?
9. How are kits developed at Fralin?
10. What kinds of changes have occurred with the kits because of teacher feedback?
11. If you were to design a kit or develop curriculum for Fralin, what types of information would you include or emphasize?
12. How have the educational standards affect the development of biotechnology kits or your relationship with teachers?
13. Describe for me what your interpretations of a teacher who uses Fralin resources?
14. What is the significance of labeling materials with Virgina BioTech? Why do you keep the labels on materials that you order from other biotechnology corporation?

Appendix B

Time Line of Study



Appendix C

Teacher Conference Interview Protocol

Virginia Polytechnic Institute and State University
Teacher Interview Schedule
Pre-Resource Visit

1. Tell me about your history with Fralin. How did you first get connected with Fralin's resources?

2. Tell me about your previous experiences with biotechnology. Did you have undergraduate or college experience with biotechnology before your began teaching? Before you began using Fralin's resources?

3. What kinds of Fralin activities do you participate? How active are you?

4. How would you describe what biotechnology means to someone who is not familiar with it? How does it affect your life personally?

5. What kinds of experiences do your students have with biotechnology? For example, other than when you cover biotechnology in your classroom, what other experiences do your students have in the course of their lives that you know of?

6. What place does biotechnology hold in your overall biology curriculum? What value do you place on biotechnology in the overall life of the classroom?

7. How do you connect biotechnology to other elements in your curriculum?

8. How has your affiliation with Fralin changed your opinion on scientific issues surrounding biotechnology in your community?

9. How has your affiliation with Fralin changed your opinion on educational issues surrounding biotechnology in your community?

10. How has your affiliation with Fralin changed your opinion on social issues surrounding biotechnology in your community?

11. How would you describe how scientific endeavors emerge from the laboratory to the classroom?

12. What other elements in your curriculum affect the way you teach biotechnology in the classroom?

13. Does using the technology make you feel a certain way?

14. Do you feel like you are treated differently by the students, faculty or parents when you use the kits from Fralin?

15. What kinds of Fralin activities do you participate? How active are you?

Appendix D

Teacher Interview Pre-Lab Protocol

Virginia Polytechnic Institute and State University
Teacher Interview Schedule
Pre-Resource Visit

1. Tell me about your community. How would you describe your students in relation to that community?

2. In what ways does your community use biotechnology?

3. In what ways do you feel like the science that emerges from Fralin representative of you or your students?

4. Where do you or your students see biotechnology in practice other than your classroom?

5. How relevant is what you are teaching to your students about biotechnology to their everyday lives?

6. In what ways do you feel like the science that emerges from Fralin representative of you or your students?

7. In what ways do you feel like the science that emerges from Fralin not representative of you or your students?

8. How has using the resources from Fralin changed your classroom or your teaching philosophies?

9. How do you make curriculum relevant for your students?

10. How is Fralin helpful in this endeavor?

11. How would you change the resources from Fralin in order to better serve you or your students?

12. If you were to design a kit or develop curriculum for Fralin, what types of information would you include or emphasize?

13. How have the educational standards that you deal with affect your teaching of biotechnology?

14. Describe for me what your interpretations of a Fralin scientist are? What route would one of your students have to travel in order to work in Fralin or be part of that community?

Appendix E

Participant Consent Forms

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Scientists

Title of Project: How Teacher Connections with Biotechnology Centers Transforms Science Teaching and Learning.

Investigators: principle investigator: John McLaughlin
Committee Chair: Dr. George Glasson
Committee member: Dr. Brenda Brand
Committee member: Dr. Gary Downey
Committee member: Dr. David Hicks
Committee member: Dr. Jan Nespor

Purpose:

In this project, I am collecting ethnographic information on how science teachers use resources from Fralin Biotechnology Center in order to elicit full student participation in biotechnology activities.

Procedures:

If you choose to participate, I would like to collect the following information:

(1) Interview of scientists to better understand your perspectives on how educational resources evolve at Fralin and how a network of communication develops between teachers and scientists. This information will be used in compiling information about how biotechnology resources can serve science classrooms with growing diversity.

(2) Audiotaped sessions with scientists in laboratory or classroom settings will be conducted. This information may be used in the analysis of how teachers use membership within and technology from Fralin Biotechnology Center in order to develop biotechnology curriculum.

(3) Artifacts directly related to Fralin Biotechnology Center, including technical equipment, protocols, and assessments of scientists' perspectives, resulting from the use of biotech kits will be examined. This information will be used to help triangulate and analyze the connections between Fralin and teachers.

Risks:

There should be no more than minimal risks to you from participating in this curriculum development project. Your responses will in no way affect your participation in the project. You can refuse to answer any questions that make you uncomfortable. You can also end the interview at any time.

Benefits:

There are no direct benefits to you, but your participation in this project might help you gain insight on how you may enhance already existing lines of communication and resources to better serve your educational public. I can also share these reflections with the science education community at conferences or in published reports.

Extent of Anonymity and Confidentiality:

Although it will not be possible to provide absolute anonymity to the participants since their identities will be known by the researcher, confidentiality will be strictly preserved. At no time throughout this research (or in any written products or presentations that follow) will participants be identified in the analysis of the project without first obtaining written consent and approval.

Freedom to Withdraw:

You are free to withdraw from participation in this ethnographic study at any time. Just inform one of the investigators listed at the bottom of the page.

By signing below, you indicate that you have read and understood the informed consent and conditions of this project, that you have had all of your questions answered, and that you give your voluntary consent for participation in this project.

If you participate, you may withdraw at any time without penalty.

____
Signature

____
Date

Investigators:

John McLaughlin 540-992-1261
David Moore 231-4991 IRB Chair.

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Teachers

Title of Project: How Teacher Connections with Biotechnology Centers Transforms Science Teaching and Learning

Purpose:

My name is John McLaughlin and under the advisement of my doctoral committee chair, Dr. George Glasson, I am collecting ethnographic information on how science teachers use resources from Fralin Biotechnology Center in order to elicit full student participation in biotechnology activities. I am interested in finding out how the industrial image of Fralin Biotechnology's outreach materials change as they enter the classroom, how these resources affect student learning and teaching practices, and how teachers communicate with Fralin while using biotechnology resources. For the two-week loan period while you will be using Fralin's outreach materials, I would like to observe your classroom and how you and your students use these materials in meaningful ways. My goal is to interview you before you use the materials with your classes, and once during the biotechnology experience. After the biotechnology experience, I would also like to conduct approximately three one-student interviews with several students in order to get their thoughts about the experience.

Procedures:

If you choose to participate, I would like to collect the following information:

(1) Approximately three, 30 minute audiotaped interviews of teachers to better understand your perspectives on how biotechnology resources from Fralin emerge in your classroom and affect your classroom practices and curriculum. This information will be used in planning and disseminating information about how biotechnology resources can better serve science classrooms with growing diversity. The tapes will be transcribed and shared with the teacher before including this information into my dissertation or any other writing or presentation I develop. I will keep these recordings for approximately five years at which time they will be destroyed.

(2) Observations of teachers in classroom settings will be conducted. This information may be used in the analysis of how classroom practices are affected by the teacher's association with Fralin and will be used to illuminate how teachers use Fralin resources in their classrooms.

(3) Artifacts directly related to Fralin Biotechnology Center, including technical equipment, protocols, assessments of teachers' perspectives, and student work resulting from the use of biotech kits will be examined. This information will be used to help triangulate and analyze the connections between Fralin and teachers.

Risks:

There should be no more than minimal risks to you from participating in this research. Your responses will in no way affect your participation in the project. You can refuse to answer any questions that make you uncomfortable. You can also end the interview at any time. I will keep all information confidential and will make every effort to keep participant name anonymous from any other participant in the study including Fralin Biotechnology Center, and your school system's administrators.

Benefits:

There are no direct benefits to you, but your participation in this project might help you develop a broader biotechnology curriculum that improves secondary science education in your school. Deeper reflection into your teaching practices and how Fralin resources intersect in your classroom may help you serve a wider group of students from different cultures. I will also be able to share our reflections with Fralin in order for them to develop a more comprehensive group of resources that can serve the public better. I can also share these reflections with the science education community at conferences or in published reports.

Extent of Anonymity and Confidentiality:

Although it will not be possible to provide absolute anonymity to the participants since their identities will be known by the researcher, confidentiality will be strictly preserved. At no time throughout this research (or in any written products or presentations that follow) will participants be identified in the analysis of the project without first obtaining written consent and approval.

When analyzing the work of students in your classes resulting from the use of Fralin resources, I will assign pseudonyms or code numbers in place of student names so that someone reading a report would probably not be able to identify the student. Every effort will be made to preserve the confidentiality of students.

Freedom to Withdraw:

You are free to withdraw from participation in this ethnographic study at any time. Just inform one of the investigators listed at the bottom of the page.

By signing below, you indicate that you have read and understood the informed consent and conditions of this project, that you have had all of your questions answered, and that you give your voluntary consent for participation in this project.

If you participate, you may withdraw at any time without penalty.

____
Signature

____
Date

Investigators:

John McLaughlin 540-992-1261
David Moore 231-4991 IRB Chair.

Appendix F

Interest Letter

1992

In recent years I have attended workshops at Rochester Medical School, the University of Virginia, Catholic University, and University of Kansas Medical School which have updated my knowledge of DNA and genetic engineering, immunology, tissue culture, and the Human Genome Project. I have shared this knowledge by conducting workshops in 1989 and 1990 on electrophoresis, DNA transformation, and the 12 AP Biology labs for 15 biology teachers in my county school system. In 1991-92 I served as Master Teacher and Editor of the Biotechnology Network for the forty teachers who had studied genetic engineering and immunology at Rochester Medical School. I compiled labs, games, tests, and class activities into a book which was published and distributed to participating teachers. In 1993, I presented two workshops for biology teachers at the [redacted] state convention. One workshop covered information on the "Human Genome Project" and the other workshop was "Techniques for Teaching Bacterial DNA Plasmid Mapping". In February, 1994, I will be giving a workshop for 15 biology teachers in [redacted] on the Human Genome Project. I am working with Dr. [redacted] at the Biotechnology Center [redacted] to help set up a workshop for teachers in July, 1994, which will include labs, lectures by professors, and field trips to labs involved in genetic engineering of plants and transgenic animals. I will be serving in 1994 on the state Biotechnology Association Education committee organized by the [redacted] Center of Innovative Technology.

I would like to network with other teachers and scientists across the country. Part of our obligation for being chosen to attend the Human Genome Project Workshop at Kansas City Medical School in June , 1993 and 1994, is to become a resource person for our state and teach our colleagues about where to find information and help when teaching about DNA. Being able to communicate through computer networking with other teachers and scientists; to find more lab activities on DNA, sequencing ,and PCR; and to share these with other colleagues are major goals that I would like to be able to accomplish.

Therefore, my proposal and requests for funds are to:

1. Take a course at [redacted] Biological Station this summer under Messrs. Burke and Timko in which I would perform lab activities such as DNA sequencing using the Sanger Method and PCR(polymerase chain reaction). This course would enable me to learn techniques that I would find useful in teaching my own students as well as other teachers.

2. Develop workshops for teachers in the state of [redacted] which will update them on the latest research in the field of genetic engineering and the Human Genome Project-a fifteen year project to map the 100,000 genes on the 46 chromosomes. Since I was one of eighty teachers selected from all over the United States to attend Kansas City Medical School in 1993 and 1994 for updating on the HGP, I would really like to work with the Virginia Biotechnology Association, the University of Virginia, [redacted], George Mason University, Medical College of Virginia, and other institutions to develop ways to assist teachers in the state.

Costs: At present, the catalogue for [redacted] summer courses is not available , but costs usually run about $800-$1000 for one session. Costs include tuition, lab fees, rent, board , and group insurance.

Appendix G

Grant Letter

Center for the Liberal Arts

University of Virginia
Post Office Box 3697
Charlottesville, Virginia 22903-0697

14 March 1994

Dr. [redacted]

Dear Dr. [redacted],

I am delighted to report that our selection committee has awarded you a $1000 Teacher/Scholar Fellowship for the coming summer to enable you to study at the [redacted] Biological Station. Your proposal stood out, even though there were a large number of excellent applications, and we were especially impressed with your project, your capacity for continued scholarly growth, and your commitment to teaching. We ask that you take advantage of this opportunity by spending at least a month of full-time work on the project unencumbered by other employment. If your grant activities take a major change from what you proposed, please let us know.

At the end of the grant period (by 15 September at the latest), we would be grateful if you could send us a brief (one- or two-page typed) report. We are interested in what you accomplish and we find that comments from fellowship winners are helpful in our campaign to increase the number of grants available to deserving teachers.

I enclose a biographic data form which will enable us to pay you the grant. Please date and sign the form, and on a separate sheet give us your social security number and the address to which you would like the fellowship check mailed. (We'll type in the information.) The form should be returned to the Center in the enclosed envelope as soon as possible.

Best wishes for a productive and enjoyable summer.

Sincerely,

[redacted]
Assistant Director

c: [redacted], Superintendent, [redacted] Public Schools
[redacted], Principal, [redacted] High School

Enclosures: Biographic data form and return envelope

Director: Harold H. Kolb Jr., Professor of English (804) 982-5203
Assistant Director: Marjorie P. Balge-Crozier (804) 982-5204
Program Coordinator: Alice F. Cook (804) 982-5205
Associate Director: R. Bruce Martin, Professor of Chemistry (804) 924-3640
Administrator: Lois N. Gibson (804) 982-5063
Fiscal Coordinator: Carolyn B. Randolph (804) 982-4790

Appendix H

Update Letter

April 26, 1994

Dr. Marjorie P. Balge-Crozier
Assistant Director
Center for the Liberal Arts
University of Virginia
Charlottesville, Virginia 22903

I wanted to update you on the course I will be taking this summer as well as some of the other activities I will be engaged in with the Biotechnology Center at [redacted]. Since [redacted] Biological Station is not offering their two week biotechnology and genetic engineering course, I have arranged to take a course at [redacted] on "Protein Structure and Analysis" in which I will be introduced to southern blotting techniques, northern blotting techniques, DNA sequencing, and other topics I had hoped to learn in the course at Mountain Lake. Dr. [redacted] in the biochemistry department will be teaching this course.

I have also met with Dr. [redacted] and [redacted] at [redacted] and presented them with a proposal for summer activities that I will be engaged in with their center. I have enclosed a copy of this proposal for your perusal.

I will be going to the National Biotechnology Education Conference at the University of Wisconsin in Madison on May 12-13, and should pick up a lot of ideas that we can put into effect in Virginia. I have included some information on that for you.

I will be presenting workshops at the Virginia Association of Science Teachers Conference next November and I will also be presenting at the National Association of Biology Teachers Conference in St. Louis.

As you can see-I will definitely be busy. I shall report to you later on my accomplishments.

Sincerely yours,

[redacted]

Teacher-Scholar

Appendix I

North Carolina Biotechnology Center Letter

NORTH CAROLINA BIOTECHNOLOGY CENTER
EDUCATION PROGRAM

SECONDARY EDUCATION PROJECT

Biotechnology education is critical if North Carolinians are to understand the technology, support its development, decide its issues, work in it, and use its products. To address this need, the North Carolina Biotechnology Center in 1986 initiated a Secondary Education Project.

The primary goal of the Secondary Education Project is to improve public understanding of biotechnology by increasing the number of secondary school students receiving biotechnology education, and improving the quality of that education. The Project is the nation's largest state-based effort to train teachers of grades 7-12 about the science, applications and issues of biotechnology. Components of the Project includes biotechnology teacher training, and teaching materials and teacher/student support services.

Teacher Training The Project conducts a sequence of two biotechnology workshops for in-service teachers at no cost. The goals are to increase teachers' knowledge of biotechnology and to show teachers how to incorporate this knowledge in their existing courses.

Introductory Biotechnology Workshops introduce teachers to basic concepts and laboratory procedures in molecular biology and biotechnology.

Advanced Biotechnology Workshops build on the basic concepts of the introductory workshop. Advanced techniques are presented and teachers are introduced to how biotechnology is being applied to areas such as agriculture and human genetics.

The workshops are conducted in university laboratories statewide by university faculty and by trained high school master teachers. Since its inception in 1987, about 600 teachers have taken the workshops. These teachers have given biotechnology lessons to more than 200,000 students statewide.

In 1993 the Center began a new *Pre-Service Teacher Training Initiative* to reach college students who are preparing to be science teachers. The first group of 42 pre-service teachers at the University of North Carolina at Greensboro were given instruction in biotechnology education in fall 1993.

Teaching Materials The Project provides free lesson plans, audio-visual aids, lab equipment and biological supplies that correlate with the introductory and advanced biotechnology workshops. In summer 1993 the draft version of a revised and updated biotechnology activities manual was distributed at the summer workshops. The manual, titled *Teaching*

Basic Biotechnology: DNA-based Technologies, serves both as a textbook, providing background information about the science and applications of biotechnology, and as a manual of activities in lesson-plan format. In the coming months, the final version of the manual will be sent to all teachers who have completed the Center's workshops.

Support Services The Project publishes a semi-annual educational newsletter, *Carolina Genes*, that provides information on scientific breakthroughs, new lesson plans, biotechnology industry news, and information on biotechnology-related topics. The project maintains a library of educational materials including print, audiovisual resources and educational software, that can be borrowed free of charge. The Center also has a teacher's learning lab where Center staff perfect new laboratory experiments for use in the classroom and where teachers can come to practice techniques or devise new laboratory-based lessons.

Career Discovery The second goal of the Project is to provide opportunities for students who are interested in biotechnology to pursue their interest. Ultimately these students will provide the trained work force needed by the biotechnology industry.

Science Fair Awards To encourage enterprising students to explore applications of biotechnology beyond what they learn in the classroom, the Project sponsors annual science fair awards for students in grades 6-12 and their teachers.

A Biotechnology Research Project was instituted in 1992 to provide an opportunity for experienced teachers to involve their students in scientific research. Ten teachers participated in a five-day intensive workshop in summer 1992 and again in summer 1993 to learn advanced recombinant DNA techniques. The teachers are using these techniques to lead their students in an ongoing collaborative project with scientists from Duke University.

The brochure *Careers in Biotechnology* was published in 1993 to help students make career decisions. The brochure describes different jobs that are available in the biotechnology industry and how much training is needed for each kind of job.

Education Enhancement Program To assist efforts by educators to improve biotechnology education and training in North Carolina, the Center in 1991 initiated an Education Enhancement Program. *Education Enhancement Grants* assist development of activities, programs, resources and personnel necessary for biotechnology education and training in the state's secondary schools, community colleges, colleges and universities.

Collaborations with universities, institutions, government agencies and corporations have been important to the Project's success. Support for the Project has come from many sources, including local and state agencies, the state university system and corporations.

For more information, contact Dr. Adrianne Massey, Educational Programs Manager; or Dr. Helen Kreuzer, Educational Programs Coordinator.

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November 1993

Appendix J

Thank You Letter

September 3, 1994

Dr. Adrianne Massey
Director, Education and Training Programs
North Carolina Biotechnology Center
Box 13547
Research Triangle Park, North Carolina 27709

Dear Adrianne:

I thoroughly enjoyed meeting with you in August and getting your suggestions concerning how to spearhead an educational initiative for high school and community college teachers. Your Center is "light years" ahead of us here in Virginia and we respect your efforts and what you have been able to accomplish since 1987.

I have received your textbook from the American Society for Microbiology Press and am in the process of my review. Overall, I am very impressed with your book and would be happy to send you a copy of my letter to ASM.

Again, thank you so much for taking time out of your busy schedule to talk with me and to share with me your experiences with workshops, loaning of equipment and supplies, newsletters, science fairs, master teachers, and curricula. Also, give my regards to Dr. Kennedy and tell her that I enjoyed meeting with her as well.

Sincerely,

[redacted]

[redacted]
Educational Coordinator
Center for Biotechnology
[redacted]

A Land-Grant University–The Commonwealth Is Our Campus
An Equal Opportunity / Affirmative Action Institution

Appendix K

University of Wisconsin Letter

04/06/94 19:26 ☎804 786 3651 T[redacted]th --- [redacted] 002/006

Univ. of Wisconsin Biotechnology Center - (608) 262-6748 - Created: Tuesday, April 5, 1994 22:54 - Page 1 of 3

Come to Terrace II:
The Second Terrace Conference on
Biotechnology Education and Public Policy

The First Terrace Conference on Biotechnology Education and Public Policy brought together representatives of 13 Biotechnology Centers and universities from California to North Carolina to meet colleagues, share insights, and plan collaborative actions.

Terrace II will be May 12-13 in Madison. We plan to meet in the evening of May 12 from 7 to 9 PM at the Wisconsin Center on the shores of Lake Mendota, on the UW-Madison campus.

On Friday May 13, from 8:30 to 4:30, we will meet at Promega's new Biopharmaceutical Technology Center Institute, which includes 20,000 sq. ft dedicated to education and outreach. The BTCI is located about 6 miles south of the UW-Madison campus at 2800 Woods Hollow Road in the city of Fitchburg. Karin Borgh, director of the BTCI, will be our host.

Terrace II is being held in conjunction with the "Biotechnology and Food" videoconference that will originate from Madison on May 12 from 1:15-3:15 Central Time.

Action Items for Terrace II include :

- Improving the impact of biotechnology centers and universities in education programs;
- Insights in Risk Communication, presented by Judy Shaw of the New Jersey Department of Environmental Protection;
- Preparing for the **International Biotechnology Education Conference** in October in San Francisco, presented by the conference's co-organizer, Mike Patrick;
- Issues of pre-market notification, food labels and biotechnology (BGH, FlavrSavr);
- Improving the usefulness of BCEPP (the Biotechnology Education and Public Policy listserver) and other means of networking.

Special Features include a tour of the new 200,000 sq. ft. **Biopharmaceutical Technology Center** which houses production facilities of Promega Corporation and of Ophidian Pharmaceuticals, and the education training and outreach facilities of the **BTC Institute** . The latter include four laboratories, two classrooms, and a 290-seat auditorium, all available for use by teachers and students. Karin Borgh will also describe the **Biotechnology Apprenticeships Program** she is developing with partners from the Madison Area Technical College, several state agencies, and industry.

Appendix L

Meeting Key Ideas

[redacted] - Biotech Meeting - KEY IDEAS

[redacted]

I. Introduction - Dr. [redacted].

Spoke briefly on grants obtained; new $9 million Biotechnology building; 4 floors. Being a land grant university - they have a mission in the state for outreach.

Spoke of [redacted] Biotech Center in [redacted] Connections with [redacted] at [redacted] to network across state. What is the Center at [redacted] doing? This summer: DNA Workshop (July) and a Protein Workshop (August). In future they may have courses on plant, animal or environmental biotechnology.

II. What can [redacted] Center for Biotech do in the future?

Suggestions were:

1. Equip footlockers with biotech equipment for loan to teachers
2. Videos for loan ([redacted] has >80 for loan)
3. Prepare a 10-minute video on Biotech @ [redacted]
4. Do a survey of teachers in the state about needs
5. Talk to newspapers about what is happening in Biotech
6. Bring a Cold Spring Harbor Course to [redacted]
7. Network with governor's schools or community colleges
8. Have head teachers or "Master Teachers" throughout the state who could give workshops to other teachers/regions?
9. Promote teleconferencing; make it more accessible.
10. Have a 1-day workshop at [redacted] Convention on November 11th in [redacted] from 9-4 pm. Limit to 35. Have labs, videos, speaker - Dr. [redacted] activities; computer network ideas; kits
11. Have a meeting at [redacted] - July 17th to "Brainstorm" ideas for [redacted] conference.
12. Have a BIOTECH Workshop - conducted by Dr. [redacted] at Thomas [redacted] Magnet School July 30th and 31st; max of 24.
13. Provide a list of professors at [redacted] who can help students with research on projects.
14. Assist teachers to get ideas together via computer networking - [redacted]
15. Speak to community college teachers at [redacted] convention
16. Compile speakers bureau - list of colleges, university and medical researchers who could speak to group.
17. More summer workshops for teachers - high school and community college
18. Newsletter out to high school, college bio teachers re conferences, workshops; sharing of labs

Appendix M

Biotechnology Consortium Letter

TO: COMMITTEE MEMBERS
VIRGINIA BIOTECHNOLOGY EDUCATION CONSORTIUM

FROM: [redacted], Administrative Assistant
[redacted], Educational Coordinator

We would like to get the committee together this spring and get input and ideas on ways that the [redacted] can assist biology faculty during the coming 1996-1997 school year. Since many of you may be coming to the [redacted] meeting that [redacted] has organized for Saturday, April 20th, here in [redacted] at the [redacted] Museum of Natural History from 10:00 a.m. to 3:00 p.m., we thought this might be a good time to brainstorm about the upcoming [redacted] conference at [redacted] on November 8-9th, the 2001 Conference at Hotel [redacted] on June 21-22, and other possible workshops. So we would like to propose meeting at the museum at 8:30 in the morning which should give us time to discuss important issues. The museum address is 428 N. Main Street in [redacted].

We also plan to meet again on Thursday, June 20th, at 3:00 at Hotel [redacted]. Since many of you may be coming to the conference on Friday and Saturday anyway, we thought this might fit well into everyone's plans. At that time we would also like to introduce a new member of our staff-Dr. [redacted] Ph.D, who will be Biotechnology Instructor and who will assume responsibility for the Center's Outreach Program.

If you have any questions, please contact [redacted] at the [redacted] Biotechnology Center at 1-[redacted].

Appendix N

"Words of Wisdom" Page from NCBC

WORDS OF WISDOM
FROM NORTH CAROLINA BIOTECHNOLOGY CENTER

FROM MEETING BETWEEN:
DR. [redacted], CENTER FOR BIOTECHNOLOGY-[redacted]
AND
DR. ADRIANNE MASSEY, EDUCATIONAL PROGRAMS MANAGER
AND
DR. KATHLEEN KENNEDY, EDUCATIONAL PROJECTS COORDINATOR

1. TRUNKS--EVERYTHING NEEDS TO BE SAFELY WRAPPED UP SO IT CANNOT MOVE AROUND!
2. WRAP THE GEL MOLDS SEPARATELY FROM THE CHAMBERS. IF YOU LEAVE THE GEL MOLDS IN THE CHAMBERS THEY TEND TO KNOCK AROUND AND CAN DAMAGE THE WIRES AND THE CHAMBER ITSELF.
3. THEIR TRUNKS HAVE WOODEN COMPARTMENTS REINFORCED WITH FOAM RUBBER.
4. SOMEONE REALLY, REALLY NEEDS TO MONITOR THE VIDEO LIBRARY VERY CAREFULLY. THEY HAVE LOST MANY OF THEIR VIDEOS AND BOOKS!! NOW THEY HAVE THEIR LIBRARIAN SYSTEM TOTALLY MONITORING IT.
5. WE CAN USE INFORMATION FROM THEIR NEWSLETTER IN OUR OWN--BUT WE MUST MAKE SURE THAT WE SAY "REPRINTED WITH PERMISSION OF NORTH CAROLINA BIOTECHNOLOGY CENTER FROM CAROLINA GENES".
6. THEY FIRST SELECTED 27 OUTSTANDING BIOLOGY TEACHERS FROM AROUND THE STATE IN 1987 AND THEN TRAINED THEM IN AN 8-DAY WORKSHOP. THEN THESE 27 TEACHERS WERE USED AS "MASTER TEACHERS" TO CONDUCT OTHER WORKSHOPS. WORKSHOPS WERE CONDUCTED AT 8 DIFFERENT COLLEGES AND UNIVERSITIES SPREAD OUT AROUND THE STATE IN REGIONS. ONE UNIVERSITY PROFESSOR AND TWO HIGH SCHOOL TEACHERS WORKED IN COLLABORATION TO CONDUCT THE WORKSHOPS. SOME UNIVERSITY PROFESSORS WORKED OUT WELL, SOME DIDN'T. DITTO WITH THE HIGH SCHOOL TEACHERS-SOME ARE STILL IN THE PROGRAM AND SOME AREN'T. THE UNIVERSITY PROFESSOR AND THE HIGH SCHOOL TEACHERS WERE PAID TO HOLD THESE WORKSHOPS. THE HIGH SCHOOL TEACHERS RECEIVED $500 EACH.(SHE DIDN'T SAY WHAT THE PROFESSORS WERE PAID. MAYBE MORE SINCE THEIR LABS WERE BEING USED?)
7. THEY DEFINITELY THINK THAT 8 DAY WORKSHOPS ARE TOO LONG. AND THEY THINK A 5-DAY WORKSHOP IS IDEAL!!!!!!!!
8. THEIR LOANER TRUNKS CONTAIN POWER SUPPLIES, CHAMBERS, MICROPIPETTORS, HOT WATER BATH, LIGHT BOXES, AND OTHER PERMANENT EQUIPMENT. THEY MAKE THE TEACHER RESPONSIBLE FOR BUYING EXPENDIBLES SUCH AS TIPS, MICROCENTRIFUGE TUBES, STAINING TRAYS, ETC.