A Thesis and Curriculum Presented by
Kara Wentworth

to
Anne Fausto-Sterling
Professor of Biology and Gender Studies
and
Lawrence Wakeford
Clinical Professor of Science Education

in partial fulfillment of the
requirements for the degree of
Bachelor of Arts with honors
in the field of
Human Biology: Race and Gender

Brown University
Providence, RI

December 2005
This is an unpublished thesis in which copyright subsists
© copyright by Kara Wentworth
December 2005
All Rights Reserved

Since this manuscript is not intended for publication, some of the charts, graphs, photos, pictures and drawings were used without permission of the authors. This copy is not for distribution to the public.
Acknowledgments

To Anne Fausto-Sterling and Larry Wakeford for their support and inspiration. To Andrew Frishman for being more than I could have ever asked for in a mentor/teacher. To Beccy and Pablo for opening their classroom doors wide. To Nancy Diaz and the entire staff of The Met: Unity. To all my “ER” students and especially the Warriors. To mom, dad, Daniel, SWB, VL, LM, BD, SS, JS, EE, AA, NG, GW, SL and SG: you’re quite a team; I couldn’t have done this without you.

And a special thanks to the C.V. Starr Fellowship Program at Brown University’s Swearer Center for Public Service for funding my teaching of the Biology of Sex and Gender curriculum.
Abstract

The thesis defines guidelines for Science Studies Education and offers two modest attempts at Science Studies curriculum design for the high school classroom. The two curricula, one on evolution and the other on the biology of sex and gender, were taught at the Metropolitan Regional Career and Technical Center High School in Providence, RI in the Fall of 2005 as part of the student-teaching component of Brown’s Undergraduate Teacher Education Program. The thesis includes an introduction and justification for each curriculum, full text of teaching materials, and reflections on the successes and challenges of each program. It concludes with an analysis of the case studies and implications for Science Studies Education in a broader context.
**Table of Contents**

Introduction: What is Science Studies Education?...........1

Literature Review: Articulating Guidelines................9

Methodology..............................................23

*Part I: Evolution*

Chapter 1 Introduction to Evolution Curriculum...........29

Chapter 2 Evolution: Biology, History, Controversy Unit..35

Chapter 3 Reflection on Teaching about Evolution.......137

*Part II: Sex and Gender*

Chapter 4 Introduction to Sex and Gender Curriculum.....147

Chapter 5 Biology of Sex and Gender Unit...............157

Chapter 6 Reflection on Teaching about Sex and Gender...170

Conclusion..............................................181

Works Cited.............................................187
Introduction

Getting Here

For my first three years of college, I planned to design an independent concentration in Science Studies, connecting philosophy of education and philosophy of science. I chose, instead, to major in Human Biology, with a focus on Race and Gender, and to earn a high school teaching certificate through Brown’s Teacher Education Program. The teacher training program has opened doors that would have otherwise remained closed: I have been granted full access to an incredible high school as part of my student-teaching experience, I have had the pleasure of meeting and working with other wonderful people who want to be science teachers, and I am now able to approach the question of how science should be taught from the unique perspective of someone who goes out and teaches it each day.

I have also been given a glimpse into the frontlines of public education. I originally imagined this thesis project would present a curriculum that I would only get to teach after graduating. Entering Brown’s teaching program allowed me to actually teach the curricula. And as I have quickly realized, planning curricula is one thing; actually teaching is another. A curriculum itself is no more than a basic script. What is actually enacted in the classroom follows, resists, and reinvents that script as it goes.

Through the process of writing, teaching and revising, I have continued to ask the intellectual questions that first attracted me to studying science and education:

What do we know and how is that knowledge made?

and
What do we teach and how is that knowledge made?

These broad questions have guided me through all four years of college, beginning with courses in Science Studies and Philosophy of Education in my first year. My understanding of how knowledge is made in science and in education has been molded by the many texts and authors I have encountered in my undergraduate course of study. I have approached the biology major and the professional degree program with my feet firmly planted in the world of philosophy of science and of education, more broadly speaking, in the field of Science Studies.

Science Studies

Science Studies is an interdisciplinary umbrella of a field, which includes scholars in history, philosophy, sociology, anthropology, religious studies, biology, literature, chemistry, physics, economics, political theory, and other fields. While it is methodologically diverse, it is unified in its subject of study: science, and in the general pursuit of the question of “how science works” (Biagioli, 1999). Within the growing body of Science Studies scholarship, there are a number of specific theorists and theories that I have found particularly useful in developing my understanding of science and education. The literature review offers an overview of those theorists and their impact on my work in science education.

Over the last ten years, Science Studies has gained a foothold in academia, with new departments and programs in Science Studies, Science and Society, or Science and Technology Studies opening and growing internationally. Studying science as a discipline is nothing new: philosophers as early as Aristotle wrestled with these
questions, and History and Philosophy of Science Departments have been around since the 1940s. But in recent years, Science Studies is becoming more cohesive, establishing a canon, and becoming more visible as a discipline. It can take years or decades for new thinking in universities to influence K-12 education, but there have been several movements in K-12 science education reform that already reflect the ideas and ideals of Science Studies.

**Existing movements**

A number of past and current science education reform movements include aspects of Science Studies in their proposals for science content and pedagogy. The Nature of Science (NOS) movement proposes that science education curricula should include discussion of the methods, principles, and foundational assumptions of science. Proponents of History and Philosophy of Science (HPS) in K-12 classrooms claim that science content should be interlaced with relevant material on the history and philosophy of science, including biographies of scientists, exploration of historic eras and movements that have influenced science, and discussion of philosophy. HPS and NOS are often used interchangeably in K-12 education, and in my review of the relevant literature, I have concluded that philosophy of science is more or less synonymous with nature of science. Both movements are primarily concerned with adding specific content to the curriculum.

Within academia, Science and Society, Science Studies, and Science, Technology, and Society are used somewhat interchangeably as department and program titles, depending on what disciplines are included in each project. In K-12 education, Science,
Technology, and Society (STS) refers to a specific movement that began in the 1980s, emphasizing organizational change in science curricula (Yager and Tweed). Science Technology and Society (STS) differs from HPS and NOS in that it proposes a new way of structuring curricula, where specific science content is taught alongside social issues through case studies or larger social themes, such as globalization, pollution, or AIDS (Leonard and Penick). Whereas NOS and HPS seek to add content to the existing curriculum structure, STS attempts to maintain much of the standard content but reform the order and context in which it is taught (Yager and Tweed).

These three movements have had varying degrees of impact in science education discourse and in actual classrooms. For the most part, HPS and NOS have been adopted by professional associations and national standards organizations, while STS has remained on the fringes of K-12 science education. What I call “Science Studies Education” draws from all three of these movements, as well as from education theorists and Science Studies scholarship, to propose comprehensive guidelines for what should be taught and how it should be taught.

Science Studies Education

Science Studies Education differs significantly from the existing NOS, HPS, and STS movements in K-12 reform, in that it approaches science from a critical perspective and acknowledges that teaching science is inherently political. When student learning is geared toward what can be easily tested (as it tends to be in high school science curricula), discrete, testable knowledge is privileged and there is no motivation to encourage students to be active, critical thinkers. NOS, HPS, and STS reform proposals have shied away from encouraging students to develop a critical understanding of science
and have instead focused on discrete, testable content and understandings of what science is.

While existing reform movements incorporate some of the ideas of Science Studies, they do not go far enough. To make real change in science education, curriculum content and pedagogy must both be re-imagined. Science Studies has more to offer than a new way of structuring learning, the incorporation of new topics, or a shift in emphasis. It also offers a different way of understanding the process of education and making meaning in classrooms.

The foundation of this understanding of education is that education, like science, is a process of creating knowledge. We do not simply choose what to teach and then go out and teach it. Instead, what is taught is created in the process of teaching and learning, by many actors and objects: teachers, students, textbooks, microscopes, chalkboards, desks, peeling ceilings, Air Force One sneakers, the World Wide Web, dead animals, formaldehyde, lab reports, an American flag, books of national standards. And I can say now, nearing the end of my first semester of high school teaching, this does not even begin to scratch the surface of the list of participants.

Science Studies Education is inherently political. Unlike the Nature of Science and History and Philosophy of Science movements, it does not aim to make science’s reach broader, but to interrogate the nature of science, ultimately leading to a stronger science. Within K-12 reform, many are weary of political agendas attempting to enter the classroom. Science Studies scholars argue that because science is part of the messy web of our social world, science is itself political and teaching and learning science is therefore necessarily political.
Science Studies Education proposes integrated changes in both what is taught and how it is taught. As John Dewey explains,

The idea that mind and the world of things and persons are two separated and independent realms—a theory which philosophically is known as dualism—carries with it the conclusion that method and subject matter of instruction are separate affairs…but since thinking is a directed movement of subject matter to a completing issue, and since mind is the deliberate and intentional phase of the process, the notion of any such split is radically false. (Dewey 164-5)

Rejecting the false dualism of method and subject matter, Science Studies Education proposes reform in content and method of science teaching to make real change in science education.

By combining some of the most useful components of existing reform movements with critical education theory and Science Studies scholarship, I have formulated a list of guidelines for Science Studies Education.

Science Studies Education:

1. Incorporates the history and philosophy of science.
2. Encourages students to study science as a discipline as well as the content knowledge the discipline has produced.
3. Presents science as a way of knowing with specific rules, methods, and characteristics.
4. Examines and questions science’s unique position of power/privilege as a narrative.
5. Makes the existing boundaries between science and society clear, and questions those boundaries.
6. Explores topics that connect biology to other disciplines and society, e.g. science and religion, science and literature, science and race, science and gender.

7. Looks at and talks about scientists as people.

8. Involves students in the process of thinking about and deciding what and how they will learn.

9. Sees education as a constructivist process that, like science, creates knowledge, and creates the world.

10. Encourages students and teachers to look critically at their own world.

11. Offers tangible hope and actions for a better future. It inherently involves students in the process of taking the theory and ideas they are learning and putting it into practice in their own lives and in the world.

12. Values students’ partial perspectives.

The literature review that follows traces the origins of each of these guidelines through Science Studies and Education scholarship.

**The Structure of the Thesis**

This is not a traditional thesis, in which a question or hypothesis is posed, traced through relevant literature, and explored through independent research, leading to some conclusions. Instead, the thesis follows a different scholarly model, in which specific programs are presented, taught, and analyzed as case studies to better understand the stated problem. This thesis model is based on a concept in education theory called “praxis”: putting theory into practice through action in the world. As Paolo Freire
defines the term, the praxis is “reflection and action upon the world in order to transform it” (Freire, 36).

The thesis project is a documentation of my own reflection and action on the world through my attempts to enact Science Studies Education in my own classroom as a student-teacher. The major components are two curricula that I created and taught at a Providence public high school in the Fall of 2005. Praxis-based research requires the researcher not only to carry out the actions she plans in the world, but to also reflect critically and honestly on the work being done. Therefore, each curriculum contains a contextualizing introduction and reflections on each lesson, and concludes with a critical exploration of the success and challenges of teaching a Science Studies Education curriculum.

This project is a beginning point in what I hope will be a long process of fleshing out and revising my own philosophy of science education. As Richard Shaull says in his foreword to Freire’s 1973 printing of *Pedagogy of the Oppressed*,

There is no such thing as a neutral educational process. Education either functions as an instrument which is used to facilitate the integration of the younger generation into the logic of the present system and bring about conformity to it, or it becomes “the practice of freedom,” the means by which men and women deal critically and creatively with reality and discover how to participate in the transformation of their world. (15)

It is my ultimate hope that Science Studies Education can become the practice of freedom for me and for my students, and that the classroom can be a place for working together to transform our worlds.
Literature Review

In this section I will review the work of the authors I have found to be most useful in education and Science Studies. The section begins with a brief history of science education reform, followed by an exploration of the most important texts that led me to each of the Science Studies Education guidelines. I have loosely organized the review by theme, beginning with current movements in reform, then moving into education theorists and finally Science Studies scholarship. Throughout, the words of specific authors trace a path to each of the twelve guidelines for Science Studies Education I have proposed in the introduction.

History of Reform

J. Myron Atkin and Paul Black’s Inside Science Education Reform: a history of curricular and policy change offers a useful synthesis of the major movements in science education reform from the 1800s to the 1950s.

One of the first popular science education movements in the US and England was the Object Teaching Movement of the early 1800s. This school of thought focused students on observing and working with a single object that was brought into the classroom. A biology class, for example, might observe and interact with a leaf or a frog through a series of lessons. Though the idea was implemented two hundred years before the current wave of ‘inquiry education,’ the two movements share much common ground. In the 1910s, the Nature Study Movement emerged as a response to the problem of urbanization. The goals of science education during this period were to get young people interested in nature, to instill an attachment to the countryside, and ultimately to
encourage them to stay in rural America. An important part of Nature Study was the publication of the *Cornell Rural School Leaflets*, one of the first large-scale curriculum dissemination programs in history. Several decades later, during the Great Depression, the focus of science education turned to conservation. The program taught students about the effects of erosion and its role in the agricultural crisis of the time.

Though John Dewey began publishing before the turn of the 20th century, it was not until the 1940s that his ideas for science education really began to take hold. While most science teaching had focused on content, Dewey’s ideas introduced a new emphasis on teaching process and problem solving skills. Learning the process of the scientific method became a core component of the curriculum. Dewey’s ideas for science education greatly inform the my own and the Met School’s philosophy of teaching and are therefore present in the curricula I designed for the teaching site.

After the Second World War, science education took on a new place of importance in schools as the cold war arms race escalated and the illustrious wartime scientists turned their attention to the home front. In 1955, the University of Illinois Committee on School Mathematics (UICSM) declared that school curricula should focus on the problems that mathematicians find most interesting, rather than practical applications like banking or making change. The corollary was that curricula would have to be designed by experts in the field. The trend quickly spread to the sciences and in 1956, the Physical Sciences Study Committee (PSSC) brought Harvard and MIT Physics experts together to work on school curricula. PSSC was the first curriculum project to receive funding from the National Science Foundation. Because the United States
Constitution leaves the decision of what to teach up to individual states, the NSF stepped into the curriculum arena cautiously.

Within a few years, NSF began funding programs in chemistry, earth science, and biology. The Biological Sciences Curriculum Study (BSCS) in Boulder began in the late 1950s and is still publishing new textbooks and curricula today. Several of the readings I used in the evolution curriculum came from the current BSCS textbook.

**Reform Today**

Current reform movements, including History and Philosophy of Science (HPS), Nature of Science (NOS) and Science, Technology, and Society (STS) propose a shift in content, in focus, and in organization of material in science curricula. The history and philosophy of science movement has existed in academia under the same name for many years, and tends to be used interchangeably with nature of science in K-12 education.

Today science, like all subjects, is largely being reformed through the creation of state-wide and national standards. There are two major publications of national science standards, the National Science Education Standards and Benchmarks for Science Literacy. In my teacher training program and in my own teaching, I have primarily used Benchmarks to guide and justify curriculum. Benchmarks for Science Literacy is a publication of the American Association for the Advancement of Science’s Project 2061, an NSF-funded program that aimed to outline new guidelines for K-12 science teaching and learning for all Americans. The emphasis on science for all is a marked shift from the original intent of the BSCS and other 1950s-era curricula, which were designed by experts in the sciences and aimed to churn out new scientists. The current mantra of “science for all” (AAAS 1993) is that teaching science effectively to all students by
relating it to their lives and a deeper understanding of what science is, will prepare the
next generation of scientists and help to build science literacy in the entire population.

Incorporating the history and philosophy of science into science teaching is seen
as an important part of science education for all. Benchmarks for Science Literacy
includes a number of chapters that focus on the history of science, including chapters on
the nature of science, nature of mathematics, and nature of technology, a chapter on
historical perspectives, and a chapter on habits of mind that focuses on the practice and
processes of science (AAAS 1993). This emphasis on incorporating history and
philosophy of science into content standards led me to the guideline that Science Studies
Education incorporates the history and philosophy of science (SSE 1).

The nature of science (NOS) movement is roughly synonymous with teaching the
philosophy of science. Proponents of teaching the nature of science argue that learning
about science should be an integral part of learning science. A National Science
Teachers Association position statement on the nature of science was adopted by their
board of directors in 2000. The preamble states,

All those involved with science teaching and learning should have a
common, accurate view of the nature of science. Science is characterized
by the systematic gathering of information through various forms of
direct and indirect observations and the testing of this information by
methods including, but not limited to, experimentation. The principal
product of science is knowledge in the form of naturalistic concepts and
the laws and theories related to those concepts. (NSTA 2000)

As Matthews, a proponent of teaching History and Philosophy of Science explains, “the
conviction that learning of science needs to be accompanied by learning about science is
basic to liberal approaches to the teaching of science” (xiii). I have translated this
conviction into the guideline that Science Studies Education encourages students to
study science as a discipline as well as the content knowledge the discipline has produced (SSE 2).

Nature of Science teaching emphasizes the rules, methods and processes of doing science. In The Nature of Science: Understanding how the game of science is played (2000), Michael Clough, another prominent advocate for incorporating NOS into science curricula, compares the doing of science to playing a game. His basic argument is that if students understand the rules and methods of the game of science, they will have a real understanding of how it operates rather than a collection of misunderstandings about what science is. Another NOS proponent, William F. McComas, directly confronts the misconceptions many people have about how science works in his essay Ten Myths of Science: Reexamining What We Think We Know About the Nature of Science. He claims that misconceptions about the nature of science mean that many people seriously misunderstand what science is and how it works. By targeting those misconceptions, he claims, people can have a better understanding of science in general and of specific content and concepts (McComas 1996).

The National Academy of Science has published Teaching About Evolution and the Nature of Science, a book of activities for teachers to use in their classrooms. The growing focus on teaching the nature of science by emphasizing the rules and characteristics of science in K-12 curricula inspired the guideline that Science Studies Education presents science as a way of knowing with specific rules, methods, and characteristics (SSE 3).

Yet another argument for explicitly articulating the rules, methods, and characteristics of science comes from Lisa Delpit’s book Other People’s Children. As
Delpit explains, “[i]f you are not already a participant in the culture of power, being told explicitly the rules of that culture makes acquiring power easier” (25). Particularly for students who come from cultures or families that are not participants in the culture of Western science, it is necessary to understand the rules, methods, and characteristics in order to be able to understand and participate in the world of science.

The assumption within guideline three that science is a way of knowing and that there are other ways of knowing, is not always included in NOS education programs. The nature of science, in many cases, is articulated only in response to misunderstandings or attacks on science, such as the evolution/intelligent design debates. The result is a defensive construction of the nature of science that aims to emphasize science’s unique place of privilege without questioning that power or comparing science to other possible ways of knowing. By emphasizing that science is one of multiple ways of knowing, I am moving away from most mainstream nature of science models and instead drawing on the work of Science Studies scholars. In contrast to current reform in NOS, HPS, and STS, what I call Science Studies Education is a critical approach to examining science, which acknowledges that both science and science teaching are political.

At times, and particularly during the ‘science wars’ of the early ‘90s, Science Studies work that looks at science as one of multiple ways of knowing has been painted as anti-science. As Matthews wrote in 1994,

“There are two broad camps discernible in the literature: those who appeal to HPS to support the teaching of science, and those who appeal to HPS to puncture the perceived arrogance and authority of science. The second group stress the human face of science, the fallibility of science, the impact of politics and special interests, including racial, class and sexual interests, on the pursuit of science; they argue for skepticism about scientific knowledge claims. For this group, HPS shows that science is one among a number of equally valid ways of looking at the world, it has
no epistemic privilege; its supposed privilege derives merely from social considerations and technological success. This group includes those influenced by postmodernist theory, and certain sociologists of science.” (9)

I disagree that any such camps exist. I believe that skepticism about knowledge claims, consideration of science as one of multiple valid ways of looking at the world, and emphasis on the human face of science increases the depth of students’ understanding of science and their ability to be participants in learning and doing science.

Showing the human face of science can help students connect to science. It can help them to own scientific knowledge, and can help them envision themselves as professional scientists in the future. It also can help students to better understand the true nature of science: science is done by people. Hiding this fact prevents students from truly understanding the nature of science. Therefore, Science Studies Education must **look at and talk about scientists as people** (SSE 7).

As Matthews explains, one of the major goals of the HPS movement in education is

…to connect topics in particular scientific disciplines, to connect the disciplines with each other, to connect the sciences generally with mathematics, philosophy, literature, psychology, history, technology, commerce and theology, and finally, to display the interconnections of science and culture—the arts, ethics, religion, politics—more broadly. Science has developed in conjunction with other disciplines; there has been mutual interdependence. It has also developed, and is practiced, within a broader cultural and social milieu. (Matthews, xv)

By **connecting the study of science to other disciplines and to social issues** (SSE 6), Science Studies Education more accurately represents the actual development and context of science in history and in the world. John Dewey also supports the idea that subject matter should be taught in its appropriate social context in his Democracy and Education. As he explains, “[i]solation of subject matter from a social context is the chief obstruction in current practice to securing a general training of mind” (67).
**Critical Education Theory**

Science Studies Education is in many ways a natural extension of progressive education theory. John Dewey and others take as a given that when students are encouraged to activate their existing knowledge, to reflect on their own learning, to develop a meta-consciousness of their processes for making meaning and learning new skills and content, and when they are actively part of evaluating and defining what and how they will learn, they learn better (Dewey 1944; Freire 1973; Brooks and Brooks 1999). This approach to teaching and learning is a part of the constructivist movement in education.

Constructivism is used to mean many different things both in and outside of the world of education. As Olson and Clough explain, “constructivism has come to mean so many different things to different people that it no longer conveys a specific meaning” (8). But, they go on to explain, constructivist education theory and practices in the classroom are well-supported and effective for teaching and learning. In the book *Practice of Constructivism*, Tobin and Tippins summarize constructivist education practice as a process in which “the teacher takes account of what students know, maximizes social interaction between learners such that they can negotiate meaning, and provides a variety of sensory experiences from which learning is built” (Tobin and Tippins, 7).

As Freire explains the constructivist perspective on how knowledge is created,

> Knowledge emerges only through invention and re-invention, through the restless, impatient, continuing, hopeful inquiry men pursue in the world, with the world, and with each other. (58)
This invention and re-invention and interaction between human and non-human actors is the process through which knowledge is constructed.

Dewey, Freire and other constructivist theorists believe that critical, reflective learning, that is done with an awareness of its own processes and broader social context, is stronger learning. Science Studies scholarship takes a similar approach to science: critical, reflective science, that is done with an awareness of its own processes and broader social context, is stronger science. It is important that Science Studies Education sees both science and education as a constructivist process that, like science, creates knowledge and creates the world (SSE 9).

John Dewey and Paolo Freire both argue that in order to learn effectively, students must be engaged in relevant learning that stems from their current context and interests. As Dewey describes, educators often assume that the material they are teaching is not inherently interesting and so they create activities, games, or rewards to try to make learning interesting. He urges educators, instead, to delve into the material and find the interest within it by connecting the material to students’ “present powers” (127). In other words, learning must be based on students’ current knowledge and context and must directly come from the everyday lives and contexts in which the students operate.

Freire proposes a more radical view of student interest. He believes that students themselves “must be among the developers of this pedagogy” (Freire 39). In other words, it is not enough for teachers to develop curricula based on students’ current lives, interests, knowledges and contexts, but students must be actively involved in determining what is taught and learned and how.
Freire’s proposal for student-teacher collaboration in determining curriculum mirrors one of the goals of Science Studies: to reveal and examine the processes through which knowledge is made. The work of Dewey and Freire inspired the guideline that Science Studies Education involves students in the process of thinking about and deciding what and how they will learn (SSE 8).

Another tenet of Freire’s philosophy of education is that education should be a process of building critical consciousness in both teachers and students. Freire refers to this critical consciousness with the Portuguese word “conscientização,” which roughly translates to ‘true consciousness.’ As he explains, students “must confront reality critically, simultaneously objectifying and acting upon that reality” (Freire 37). Science Studies Education must, as Freire argues, encourage students and teachers to look critically at their own world (SSE 10), and beyond that, to engage in action in the world (SSE 11).

Science Studies

Science Studies scholarship covers a wide range of fields and disciplines, including but not limited to the humanities, critical and cultural theory, the hard sciences, social sciences, and the arts. As described in the introduction, Science Studies is unified by its subject of study (science) and by the question of “how science works” (Biagioli 1999). Science Studies scholarship cannot be easily summarized, but the authors I have found most useful approach science with a critical eye, believing that exposing and understanding the what and how of science will create a stronger and more useful
One aspect of Science Studies scholarship that meshes particularly well with constructivist education theory is the idea of multiple knowledges and partial perspectives. As Donna Haraway describes in her essay “Situated Knowledges,” rather than only accepting knowledge that claims to come from nowhere, knowledge should be privileged if it comes from a specific body, if it is the specific partial perspective of an individual human in an acknowledged body. If multiple embodied standpoints could be brought together, Haraway argues, this would create a stronger and more useful knowledge than knowledge that claims to be objective and disembodied (Haraway 176-177). This concept of the importance of recognizing and privileging multiple points of view is mirrored in Brooks and Brooks’ synthesis of the basic tenets of constructivist education:

"Teachers seek and value students’ points of view. Teachers who consistently present the same material to all students simultaneously may not consider students’ individual perspectives on the material to be important, may even view them as interfering with the pace and direction of the lesson. In constructivist classrooms, however, students’ perspectives are teachers’ cues for ensuing lessons.” (Brooks and Brooks ix)

The combined work in Science Studies and constructivist education led to the guideline that Science Studies Education **values students’ partial perspectives** (SSE 12). In the context of multiple perspectives, Science Studies approaches science as **one of multiple ways of knowing** (SSE 3) and examines and questions science’s unique position of **power and privilege as a narrative** (SSE 4).
As I described in the review of HPS literature, questioning science’s claim to objectivity is sometimes seen as an attack on science and on science education, rather than a valuable critique aimed at strengthening science and science education. The guidelines that propose a critical perspective on science and its position of power will likely be the most contentious among educators and theorists who oppose the Science Studies Education program. I argue that they are also among the most important and defining guidelines of this project.

This perception is advanced by Matthews, one of the primary scholars in K-12 HPS education, whose work was reviewed above.

“For all its faults, the scientific tradition has promoted rationality, critical thinking and objectivity...[t]hese values are under attack both inside and outside the academy. Some educationally-influential versions of postmodernism and constructivism turn their back on rationality and objectivity, saying that their pursuit is Quixotic. This is indeed a serious challenge to the profession of science teaching.” (Matthews, xv)

While Matthews might be somewhat less opposed to the proposed guidelines today than he was when writing in 1994, his opposition to ‘educationally-influential versions of postmodernism and constructivism’ underscores how controversial and how important a critical perspective on science is in Science Studies Education.

Science Studies Education also adds a critical element to the existing Science, Technology, and Society curricula that teach science through social issues. Science Studies Education goes beyond just teaching themes that combine science and society, to examine the very separation of science and society, by making the existing boundaries between science and society clear, and questioning those boundaries (SSE 5).

Science Studies theorist Karen Barad speaks of interlaced elements not as interacting, but as intra-acting, emphasizing that they are inseparable elements (Barad 5). If science and...
society are understood as intra-connected, it is interesting to examine where the boundaries are constructed between science and society, and to what end. As I will discuss later, the separation of science and religion and science and social issues within the evolution v. intelligent design debate was a fascinating and challenging site to explore in teaching about evolution.

Another Science Studies text I have found particularly useful to understanding the connections between science and society is Bowker and Star’s Sorting Things Out: *Classification and its Consequences*. The authors describe the many *intra-*connections between different human and non-human actors, texts, social issues, political movements, and other players in the world as ‘lilliputian threads,’ small invisible strands that connect all of these elements and, though usually hidden, are themselves responsible for much of the work that is usually attributed to the more visible elements of the world (Bowker and Star, 34).

The final guideline for Science Studies Education was inspired primarily by the work of Donna Haraway, one of my favorite Science Studies scholars. The challenge before us, she claims, is how to have a critical understanding of science and how scientific knowledge is made,

*and* a no-nonsense commitment to faithful accounts of a “real” world, one that can be partially shared and friendly to earth-wide projects of finite freedom, adequate material abundance, modest meaning in suffering, and limited happiness…[w]e need the power of modern critical theories of how meanings and bodies get made, not in order to deny meaning and bodies, but in order to live in meanings and bodies that have a chance for a future. (Haraway, 175)

Haraway’s writing is dense and often difficult to pull apart, but this passage has been so inspiring to me in the last four years that I have referenced it in almost every major paper
or project I have completed. The passage offers me tangible hope for the future, and reminds me of the importance of critical accounts of how we make meaning and make knowledge as a way of creating a viable and better future.

It is crucial that Science Studies Education not simply encourage students to have a deep, critical understanding of science and the world, but that it helps them to build a vision for the future and to take tangible action toward that vision. As Pastor, et al. describe in *Makin’ Homes: An Urban Girl Thing*,

> Critical insights without opportunities for students to reconstruct a world rich in the wonders of race, culture, gender, and social justice may wound a sense of possibility…without engaging in an activist pedagogy that educates students of color in the history and politics of successfully fighting conditions of injustice, well-meaning educators may risk exposing students to a sense of disempowerment. (Pastor et al., 29-30)

Rather than exposing students to disempowerment, Science Studies Education offers **tangible hope and actions for a better future. It inherently involves students in the process of taking the theory and ideas they are learning and putting it into practice in their own lives and in the world** (SSE 11). By having students put what they are learning into action, Science Studies Education is a process of creating both a vision for a positive future and real change in the present world. It is through action that the curriculum can become inspiring, hopeful, and liberatory.
Methodology

Overview

The preceding literature review samples the texts and authors I have found useful in defining “Science Studies Education” and in creating and teaching the unit plans. It is out of the context of this research that I have created the two curriculum projects that form the body of the thesis.

The body of the thesis consists of two distinct projects, each with its own rationale and methodology. The first project is a teaching unit with lesson plans for a high school unit on the biology, history, and controversy of evolution. The second project is a less formal series of workshops on the biology of sex and gender. Each project strives to incorporate Science Studies concepts and content into the world of high school biology classrooms. I will here lay out a very basic overview of each project. The methodology and rationale for each is discussed at greater length in the introduction directly preceding each unit.

I drafted both unit plans in the 2004-2005 academic year in preparation for student-teaching in the Fall of 2005. During this fall semester, I am student-teaching full-time at The Metropolitan Regional Career and Technical High School. I have taught the unit plans in two mixed-gender, mixed-grade 9th and 11th grade classes, one all-female mixed 9th and 11th grade class, and one mixed-gender 12th grade class. Each class contained about 15 students and met once or twice a week for 30 minutes to an hour at a time.
**Teaching Site and Students**

My student teaching site was the Metropolitan Regional Career and Technical Center, a state-sponsored progressive charter school in Providence, RI. The student body is 40% Hispanic, 30% African American and 30% White, with approximately 85% of student qualifying for free or reduced lunch. The building I taught in is located in the South Side of Providence, a largely Hispanic low-income neighborhood about two miles from the pristine Brown University East Side neighborhood I lived in for most of my college years.

The school is founded on the principle that students learn best when they are actively pursuing their own passions and interests. Students spend two full days each week out at their internship sites, and the vast majority of the work they do within school is self-directed and related to their internship work or other goals and interests. The Met is made up of six separate schools, each containing 8 advisories of 15 students, for a total of 120 students per school. Each advisory has just one advisor for all four years of high school, and that advisor is responsible for working with the student and his or her family to design, implement, and coordinate a personalized education plan.

The learning plan details the specific projects the student will be involved in for the coming quarter and requires students to explain how the work meets the school’s five learning goals and how they will document their work for their end-of-quarter exhibition. The learning goals roughly mirror traditional subjects but focus on process and critical reasoning more than content. The goals are: empirical reasoning (science), quantitative reasoning (math), social reasoning (social studies), communication (English), and personal qualities. At the end of each quarter, each student gives a one-hour exhibition of
the work s/he has done for her/his advisor, family, peers, mentor at the internship site, and other members of the school and outside community.

As a student-teacher, I took on part of the role of advisor, adopting three students as my own personal advisees, and developed a series of formal classes for 9th, 11th, and 12th graders. The formal classes fell into four separate units: an evolution unit for two mixed-grade 9th and 11th grade classes; a biology of sex and gender unit for a female-only mixed-grade 9th and 11th grade class; an evolution, race, and racism unit for a 12th grade advisory, and a sex, gender, and sexuality unit for the same 12th grade advisory. The thesis focuses on my work with the 9th and 11th grade students through my evolution and biology of sex and gender teaching units, and touches on the work I did later in the 12th grade advisory.

*Evolution: Biology, History, Controversy*

It isn’t difficult to justify the need for a comprehensive curriculum on evolution in our current social and political climate. School districts all over the country are proposing that ‘intelligent design,’ the most recent brainchild of creationism, be taught in science classrooms alongside evolution. In response we are seeing a wave of trials reminiscent of the famous Scopes trial of 1925, complete with expert witnesses debating the merits of the theory of evolution.

The mantra of the intelligent design camp is “teach the controversy,” a call that appeals to the American ideal of freedom of speech and open disagreement (Goodstein 2005). While some scientists and science teachers think the ‘controversy’ should be saved for the social studies or religion classrooms, I chose to teach the controversy within
the evolution curriculum, but to very different ends than those of the intelligent design proponents. Rather than teaching intelligent design as an equally valid competing theory, the curriculum uses the evolution controversy to explore the bigger questions of how scientific knowledge is made, why science and religion are placed at odds, and what is at stake in determining what students learn in school.

The curriculum was devised, from the beginning, as a formal lab class for Met School students in two mixed 9th and 11th grade advisories, and I revised the unit plan before teaching it with the help of the advisors of the two classes. In teaching the unit, I was forced to cut out several parts for the sake of time, and ended up sacrificing the part of the curriculum I was most excited about: examining the connections between racism and the fight over teaching evolution in schools. Fortunately, I had the opportunity to design a 3-session unit focusing solely on race and evolution for a group of 12th graders. I imagine that other educators might use the longer curriculum as a way to teach about evolution as part of a formal semester or year-long biology class. The section on race and evolution might be used as an interim section at the end of a formal unit on evolution, or else would be appropriate for a social studies classroom or might be expanded into a longer collaboration between a biology and social studies teacher.

**Biology of Sex and Gender**

The threat of violence demands urgency. And the simplest rationale for teaching a curriculum on sex and gender to all students is to change attitudes about transgender, transsexual, and intersex people with the hope that knowledge can fight violence committed out of fear and ignorance.
However, the demand for the curriculum goes beyond the need to combat violence. Many of the problems that adolescents of all genders face are based in gender roles and expectations. Teen pregnancy, date rape, bullying, eating disorders, sexually transmitted infections and gangs are all built on prescribed ideas of what young men and women are supposed to do and be like. For all students, thinking about how cultures create gender expectations and how they themselves fit into or do not fit into those molds can be a liberating experience.

I originally designed the Biology of Sex and Gender curriculum as a full four-week interdisciplinary unit for 9-11th grade students at Feinstein High School in Providence, RI. I had previously spent a semester observing a science classroom at the school and saw the collaboration between science, math, and humanities teachers as a wonderful opportunity for teaching about the biology of sex and gender. I ended up teaching instead in a very different environment, at the Met School, where students are in small classes working on self-designed projects related to their interests and passions, and formal lessons are a rare occurrence. I redesigned the curriculum as a series of workshops on gender for young women in 9th and 11th grade, and later for a mixed-gender 12th grade class. The workshops could be taught in 3-6 sessions with a consistent group of students at another high school or at a non-school community organization. I hope that as I work with other schools and community groups, I will have the opportunity to share the curriculum with other educators to meet the needs of their students.

Format and Order of the Thesis
The thesis contains three chapters on each of the two units, for a total of six chapters. Chapter one introduces the Evolution unit and establishes the motivations and need for the curriculum. Chapter two contains the unit plan, lesson plans, and teaching materials from the eight-week unit. Within each lesson plan is an explanation of the goals and objectives for each lesson, as well as a reflection on the experience of teaching that class. Chapter three is a reflection on the teaching unit, written after I finished teaching the entire curriculum, and with an eye to evaluating how well I met the goals I have defined for Science Studies Education.

Chapter four introduces the biology of sex and gender workshops and describes the need for this curriculum for all students. Chapter Five consists of less formal agendas for each day, plus a brief reflection on teaching, and student work or questions from each workshop session. Chapter Six is an overall reflection on the experience of teaching, focusing on boundaries in the classroom, intersections with race and class, and connections to the guidelines for Science Studies Education. Following the last chapter is my conclusion, in which I analyze the successes and challenges of the two curricula, and draw out implications for Science Studies Education in my own future teaching and in a broader context.
Chapter One: Introduction to Evolution Curriculum

“the campaign of William Jennings Bryan against science and in favor of obscurantism and intolerance is worthy of serious study. It demands more than the mingled amusement and irritation which it directly evokes.”

--John Dewey

It is eighty years after the Scopes trial and the campaign of William Jennings Bryan is alive and well. As a recent Gallup poll documented, less than a third (28%) of Americans accept the theory of evolution, and nearly half (48%) believe in creationism (Gallup). A trial that some are calling the second Scopes trial (MacDonald 2005)—complete with expert witnesses—opened in Dover, Pennsylvania, and Georgia schools were ordered earlier this year to remove the warning stickers that “evolution is a theory, not a fact” from their students’ textbooks. In the context of widespread public disagreement and debate, the topic of whether and how to teach evolution looms large.

In the May 3, 2005 Christian Science Monitor, G. Jeffrey MacDonald described the current climate for teaching evolution. As he describes, students are increasingly coming to class equipped with materials distributed by intelligent design (ID) proponents, including their list of ten questions to ask your science teacher, meant to stump the teacher and discredit the theory of evolution. Intelligent design is the newest incarnation of the anti-evolution movement and its proponents are using new and more successful tactics than ever before. In contrast to earlier creationist movements, ID leaves religion out of the conversation, offers scientific evidence to counter the theory of evolution, demands in the name of science that this material be included in school curricula, and rather than targeting state or federal policy, works with individual school districts, schools, students, and parents to get the material into the classroom. The list of ten
questions, which my students read as part of their analysis of the debates, is one of a plethora of educational materials produced by the main ID think tank, Discovery Institute in Seattle. In addition to explicit questions for students to ask, the Institute offers videos, modular teaching units for teachers to use in the classroom, and study guides for students (Discovery Institute).

The Discovery Institute’s website (discovery.org, not to be confused with discovery.com, the Discovery Channel’s site or discover.com, Discover Magazine’s) is one of the most well-designed, authoritative, and navigable sites I have encountered. The background is a soothing blue-grey color, and the introduction page lists upcoming events, links to articles by fellows of the institute, and recent articles from prominent journals. The phrase “intelligent design” does not appear once on the main page, but what does appear is a beautiful slogan: “Discovery Institute, Making a positive vision of the future practical.”

Who wouldn’t want to see a positive vision of the future made practical? And what excellent use of words traditionally used to promote true scientific enterprise: a positive vision, practicality, improving the future. The Intelligent Design movement has gotten better at using scientific rhetoric than even scientists themselves are. ID proponents call for a “more objective science,” unbiased research, consideration of all sides of a debate, and the valuing of academic freedom. As a recent open letter to the Kansas State Board of Education, posted on the discovery.org site states:

> Intellectual freedom is fundamental to the scientific method. Learning to think creatively, logically and critically is the most important training that young scientists can receive. Encouraging students to carefully examine the evidence for and against neo-Darwinism, therefore, will help prepare students not only to understand current scientific arguments, but also to do good scientific research (Skell).
Though the arguments of Intelligent Design proponents sound a lot like claims that any good science teacher would make, in the words of MacDonald, Intelligent Design is little more than “a well-funded effort to get religion into the science classroom.” And this effort is nothing new.

Long before and ever since Darwin’s publication of the Origin of Species, there has been active debate within the scientific community on how life came to be. In the 150 years since Darwin, new discoveries in archaeology, physical anthropology, molecular genetics, and mathematical modeling have come to support the basic tenets of evolution and to mold specific aspects of the theory of evolution based on new combinations of evidence. On the periphery of this general consensus on evolution and scientific debates, there have always been anti-evolutionists offering a religious explanation and refuting scientific claims. The struggle between free secular thought and religious doctrine long predates Darwin, and ever since the historic Scopes trial in Dayton, Tennessee, U.S. public high schools have been a prime battle ground.

In the current climate, a lot is at stake in how we teach evolution. As two Colorado State University biologists wrote in the journal *Evolution*, “[w]hat is at stake is more than just evolution; this debate is fundamentally about how science is taught in primary and secondary schools” (Antolin, 2379). I would argue that there is even more at stake, and that the teaching of evolution has major implications outside the school arena: in the separation of church and state, government support for scientific research, partisan politics, education inequity, and personal rights.

It is tempting to reject the proponents of creationism and ID, but as John Dewey said, such arguments are “worthy of serious study,” and in this treatment of the debates, I
have attempted to give them just that. However, I do not find the ID arguments worthy of much *scientific* study. Each and every one of their claims: the design of the eye, the false drawings of Haeckel’s embryos, the refutation of the pepper moth story, has been refuted by noted scientists, and many of their questions and claims fundamentally misunderstand or misuse the goals of science (Miller). Instead, I find the history of controversy worthy of study to better understand concerted movements to control what Americans learn and believe.

It is also tempting to remain on the defensive and respond to each of the ID movements claims one at a time in the classroom. I do not want my students to walk away thinking there are two sides to a scientific debate here. Instead, there are many possibilities and questions within the scientific community, and there is a separate group of people whose ideas for the most part have not borne out to peer review and scientific testing, but who are determined that their material be taught in science classrooms. I do not want to give creationism and evolution equal time in the classroom. Even if I think I am helping students to distinguish between scientific and non-scientific material, equal time is a triumph for the ID movement.

Instead, I want to approach the material from a different perspective. I intend to include a varied and thorough treatment of the theory of evolution, a review of the history of controversy and debate within the scientific community and of the creationist movement, and an exploration of what is at stake in the debates today.

As the national science standards book “*Benchmarks for Science Literacy*” explains,

*The educational goals should be for all children to understand the concept of evolution by natural selection, the evidence and arguments that support it, and its*
importance in biology. The study of this history provides a good opportunity to feature the importance in science of careful observation and description and to illustrate that not all scientific advances depend on experimentation. Also, the history of this episode should be brought up to the current times with regard to its acceptance and rejection by people. (AAAS)

Earlier this year, a Georgia school district was brought to trial for placing stickers at the front of Ken Miller’s high school biology textbook, stating that “Evolution is a theory, not a fact, regarding the origin of living things… This material should be approached with an open mind, studied carefully, and critically considered” (Holden 2005). As Miller explains in a Boston Globe opinion piece (Miller 2005), the sticker implies that evolution is the only part of biology that should be given careful, critical consideration, when in fact, all of biology should be approached with such an eye. This curriculum will explore the nature of scientific inquiry in order to encourage students to approach all expertise with a critical eye.

I have used a number of ideas from the National Academy of Sciences for teaching the nature of science through the theory of evolution. The teaching unit I have devised will come after an introductory unit on the nature of scientific inquiry. The unit on evolution will be an extension of the introduction to biology, and will expand students’ understanding of what science is, how science is done, and how scientific truth is made. A summary of the key ideas in the curriculum appears below:

- Rather than focusing on the specific claims of ID theorists, focus on the history of the controversy, the current debates, and why this controversy exists in the first place
- Rather than rebutting ID claims or comparing the two ideas side-by-side, connect the conflict to larger social conflicts and analyze the evolution-creationist controversy in the context of other social movements (e.g. racial equality).
- Show that there is a lot at stake in what is taught in schools
- Encourage students to think about who gets to decide what they learn and to have them play a role in that process
Implementing the Curriculum

This teaching unit is one of several curricula I have developed as part of my senior thesis project. I had the opportunity to teach the unit this Fall at the Met Center High School in Providence, RI. The school, as described in the methodology, has a very non-traditional format, where students spend at least two full days at internships and only three days in the classroom each week. Students are in advisories of only 15 students and they have only one teacher (called an advisor) for their entire four years at the school. The Met philosophy is that students will learn the basics through real world work and collaboration with other students and advisors in the classroom, not because they have to, but because they are interested and engaged. Designing a more traditional science unit for this school was a challenge, and the unit I originally devised changed enormously as I spent more time in Met classrooms observing what does and does not work. The unit I designed is geared toward Met students but could be adapted for another school with some structural changes.

Beginning in my student-teaching semester, Fall 2005, the Met began an experiment with its first mixed-grade classes, mixing 15 9th graders and 15 11th grade transfer students together into two classes of 15 students each. I taught the evolution curriculum to both classes, for one or two 30-60 minute sessions each week, plus trips and special guests. Before I began teaching, I revised the curriculum in collaboration with the two advisors to fit the curriculum to their and their students’ needs and I continued to revise each lesson after teaching it to one class and before trying it again with the second class. The teaching unit is still very much a work in progress, and I plan to continue to teach and revise it in the coming years.
Chapter Two: Evolution: Biology, History, Controversy

Unit Plan: Evolution: Biology, History, Controversy

(Kara Wentworth Fall 2005)

Overview: This is a four week unit on evolution, taught through biology, history, and past and current controversy around the teaching of evolution. In the first three weeks of the semester, students will answer the questions “what is scientific truth? How is it made? and Who makes it?”, and will have a basic understanding of the scientific method, observation v. inference and theories in science. The final projects will be a proposal (or multiple proposals) for a formal school-wide policy on teaching evolution and an individual portfolio of the lab work each student did with reflections. The program is intended to be taught at the Met school in Providence, RI to two classes in Fall 2005. Each class will be made up of fifteen 9th and 11th graders. The classes that are specifically designated as “joint” will bring all thirty students together.

Essential Questions: What is the theory of evolution? Why is evolution such a big deal? Who decides what you learn in school?

Guiding Questions:
• What is observation? What is inference?
• What is a theory? How is the term used in science V. outside science?
• How did the theory of evolution evolve?
• How is the evolution controversy linked to the struggle for racial equality?
• What’s happening in Kansas?
• How should we teach evolution at the Met?

Standards (Benchmarks for Science Literacy):
1B The Nature of Science: Scientific Inquiry
• In the short run, new ideas that do not mesh well with mainstream ideas in science often encounter vigorous criticism. In the long run, theories are judged by how they fit with other theories, the range of observations they explain, how well they explain observations, and how effective they are in predicting new findings.

1C The Nature of Science: The Scientific Enterprise
• Progress in science and invention depends heavily on what else is happening in society, and history often depends on scientific and technological developments.

5F The Living Environment: Evolution of Life
• Small differences between parents and offspring can accumulate (through selective breeding) in successive generations so that descendants are very different from their ancestors.
• Individual organisms with certain traits are more likely than others to survive and have offspring. Changes in environmental conditions can affect the survival of individual organisms and entire species.
The basic idea of biological evolution is that the earth’s present-day species developed from earlier, distinctly different species.

Molecular evidence substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched off from one another.

Natural selection provides the following mechanism for evolution: Some variation in heritable characteristics exists within every species, some of these characteristics give individuals an advantage over others in surviving and reproducing, and the advantaged offspring, in turn, are more likely than others to survive and reproduce. The proportion of individuals that have advantageous characteristics will increase.

The theory of natural selection provides a scientific explanation for the history of life on earth as depicted in the fossil record and in the similarities evident within the diversity of existing organisms.

7F Human Society: Social Conflict
- Conflict between people or groups arises from competition over ideas, resources, power, and status. Social change, or the prospect of it, promotes conflict because social, economic, and political changes usually benefit some groups more than others. That, of course, is also true of the status quo.
- Conflicts are especially difficult to resolve in situations in which there are few choices and little room for compromise. Some informal ways of responding to conflict—use of pamphlets, demonstrations, cartoons, etc.—may sometimes reduce tensions and lead to compromise but at other times the may be inflammatory and make agreement more difficult to reach.

10H Historical Perspectives: Explaining the Diversity of Life
- Prior to Charles Darwin, the most widespread belief was that all known species were created at the same time and remained unchanged throughout history. Some scientists at the time believed that features an individual acquired during its lifetime could be passed on to its offspring, and the species could thereby gradually change to fit its environment better.
- Darwin argued that only biologically inherited characteristics could be passed on to offspring. Some of these characteristics were advantageous in surviving and reproducing. The offspring would also inherit and pass on those advantages, and over generations the aggregation of these inherited advantages would lead to a new species.
- By the 20th century, most scientists had accepted Darwin’s basic idea. Today that still holds true, although differences exist concerning the details of the process and how rapidly evolution of species takes place. People usually do not reject evolution for scientific reasons but because they dislike its implications, such as the relation of human beings to other animals, or because they prefer a biblical account of creation.

12A Habits of Mind: Values and Attitudes
- Know why curiosity, honesty, openness, and skepticism are so highly regarded in science and how they are incorporated into the way science is carried out; exhibit those traits in their own lives and value them in others.

Performance Goals/skills:
Students will understand:
- the basic concept of evolution by natural selection
- the scientific v. popular definitions of “theory” and how the word is used in creationism/intelligent design v. evolution debates.
- why anyone cares what is taught in schools, who decides what they are taught, and why evolution is such a ‘hot topic.’

Students will be able to:
- look critically at their own ideas about what is true and what type/s of expertise they believe.
- carefully observe data, verbalize observations, and make inferences from observations.
- accurately record the work they do in our class and complete a lab report.
Assessments:
- Lab reports:
  - Candle observation
  - Cockroach mystery
  - Darwin’s finches
  - RISD nature lab
- Final Assignments:
  - Proposal for Met policy/curriculum
  - Final portfolio of work

Activities:
- Step in/Step out intro
- Observing a candle
- Observation v. inference: footprints
- The problem of pests: introducing natural selection
- Careful observation and scientific illustration
- Writing reflection: “evolution”
- Darwin’s Finches
- Controversy Jigsaw Reading
- Who decides what you learn?
- What do you think should be taught?
Week One: Intro

10 minute introductory activity (step in/step out) and student questionnaire

Week Two: What is science and introducing evolution I

<table>
<thead>
<tr>
<th>NOS #1</th>
<th>NOS #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is science?</td>
<td>How is scientific truth made?</td>
</tr>
<tr>
<td>Consensogram activity:</td>
<td>1. candle observation lab: students carefully observe a burning candle and record their observations.</td>
</tr>
<tr>
<td>Students will create bar graphs by placing their votes (one post-it note per student) on several charts on the wall.</td>
<td>2. several of the “extension” questions on the lab will ask students to make inferences based on their observations.</td>
</tr>
<tr>
<td>Questions and specific activity will be designed based on student questionnaires from week one.</td>
<td>3. Discuss the difference between observation and inference.</td>
</tr>
<tr>
<td></td>
<td>4. Debrief lab: what information was given to you? what did you find? List the basic components of a lab report on the board.</td>
</tr>
</tbody>
</table>
Week Three: What is science and introducing evolution II

<table>
<thead>
<tr>
<th>NOS #3</th>
<th>NOS #4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What is a theory? How is it used in science/outside?</strong></td>
<td><strong>The problem of pests:</strong> understanding natural selection</td>
</tr>
<tr>
<td>Ask students to collect definitions of “theory”: their personal</td>
<td>This activity is adapted from the National Academy of Sciences’</td>
</tr>
<tr>
<td>definitions, ones found online, in classroom books, and in</td>
<td><em>Teaching about evolution and the nature of science.</em></td>
</tr>
<tr>
<td>dictionaries. Have students write these definitions on large note cards.</td>
<td></td>
</tr>
<tr>
<td>Explain that there are two different definitions of “theory,” one is</td>
<td></td>
</tr>
<tr>
<td>specific to science, and one is used commonly outside of science.</td>
<td></td>
</tr>
<tr>
<td>Separate the definitions students found into “theory” in science V.</td>
<td></td>
</tr>
<tr>
<td>“theory” outside of science. Allow for overlap and some definitions</td>
<td></td>
</tr>
<tr>
<td>that might be ‘in the middle.</td>
<td></td>
</tr>
<tr>
<td><strong>Footprints: Observation v. Inference</strong></td>
<td></td>
</tr>
<tr>
<td>1. show first segment of two sets of footprints, ask students to</td>
<td>Students will be introduced to a problem that a Met teacher was</td>
</tr>
<tr>
<td>come with as many observations about the prints as possible, and to</td>
<td>having with roaches: after spraying with a pesticide “X,” almost all</td>
</tr>
<tr>
<td>make inferences from them. (distinguish between the two as each</td>
<td>of the roaches were killed but in a few weeks, there were many of</td>
</tr>
<tr>
<td>statement is offered)</td>
<td>them again. After spraying again, most of the roaches were killed but</td>
</tr>
<tr>
<td>2. show the second segment, ask for observations and inferences</td>
<td>again there were many in a few weeks. After s/he sprayed three more</td>
</tr>
<tr>
<td>3. show the third segment, ask for observations and inferences</td>
<td>times, he realized that the spray was becoming less and less effective.</td>
</tr>
<tr>
<td>4. how do we know what we know? what are alternate possibilities we</td>
<td>If our class was hired to figure out what the problem is, what questions</td>
</tr>
<tr>
<td>still haven’t thought of?</td>
<td>would we ask? What experiments would we do? The activity will</td>
</tr>
<tr>
<td></td>
<td>eventually guide the class to evidence that natural selection led</td>
</tr>
<tr>
<td></td>
<td>each generation to be more resistant to the pesticide.</td>
</tr>
<tr>
<td>Lab</td>
<td>Discussion</td>
</tr>
<tr>
<td>-----</td>
<td>------------</td>
</tr>
<tr>
<td>Activity: looking at Darwin’s finches</td>
<td>Is the controversy about teaching evolution new?</td>
</tr>
<tr>
<td>We will begin with an enacted model outdoors with students using utensils to represent differently shaped beaks.</td>
<td>A brief history of the scopes trial, through primary and secondary source documents:</td>
</tr>
<tr>
<td>Students will analyze the data from the model, and discuss the activity. They will then come inside and try to come up with multiple explanations for the population sizes of finches with different beaks on each island, using drawings, maps of the islands, and other original materials.</td>
<td>-a page from the textbook “A Civic Biology”</td>
</tr>
<tr>
<td>Finally, they will be asked to explain how the model we used previously might be adapted to represent what has happened to the Galapagos island finches.</td>
<td>-the Tennessee anti-evolution act</td>
</tr>
<tr>
<td></td>
<td>-biographies of 3 major players in the Scopes trial</td>
</tr>
<tr>
<td></td>
<td>-political cartoons related to the Scopes trial.</td>
</tr>
<tr>
<td></td>
<td>The lesson will be taught by the advisor of each class using the lesson plan and materials I provide.</td>
</tr>
</tbody>
</table>
Week Six: Lamarck’s Theory of Evolution: debunking misconceptions

<table>
<thead>
<tr>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>How can a theory that is no longer accepted help us better understand how evolution really does work?</strong></td>
</tr>
<tr>
<td><strong>A. Review of past activities:</strong></td>
</tr>
<tr>
<td>How can we explain evolution by natural selection through the cockroach mystery? Through the finch lab and model?</td>
</tr>
<tr>
<td>Hand out a text that directly confronts Lamarckian misconceptions about how evolution happens. Have students read aloud and paraphrase as they go through the text, emphasizing the idea that acquired characteristics CANNOT be passed down.</td>
</tr>
</tbody>
</table>
Week Seven: Current Controversy

<table>
<thead>
<tr>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What’s happening in Kansas?</strong></td>
</tr>
</tbody>
</table>

Based on current articles and texts, students will explore the current debates about teaching evolution. The law in question and major players will be introduced, as well as the organizations supporting each group.

Students will work on one article each in a group of five and then regroup to share their article with other students. By the end of the class, every student will have a basic understanding of all five articles and positions.

Before they leave, students will be asked to write a reflection on how they think evolution should be taught in schools. I will use these exit tickets to plan the groups for the final activity next week.
## Week 8: How should we learn about evolution?

<table>
<thead>
<tr>
<th>Guest Speaker</th>
<th>Group Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who decides what you learn?</td>
<td>How should we teach evolution at the Met?</td>
</tr>
<tr>
<td>All the students will be in their first year at the Met school, and will have the memory of another school close at hand. Special guest Ben Bruder, who is in charge of school curriculum for all 600+ Met students. He will discuss how content is determined at the Met school and how this is different from more traditional public schools.</td>
<td>Students will be asked to think about how evolution should be taught at the Met school: should there be a school policy? Should there be a mandatory curriculum? If so, what should be included?</td>
</tr>
<tr>
<td>Students will break into groups of three to draft a proposal for a school policy and curriculum guidelines.</td>
<td>The whole class will come back together, look at proposals, and see if there is one proposal they can agree to send to Ben and the school principals.</td>
</tr>
</tbody>
</table>
# Evolution Unit Plan Calendar

## August- September

<table>
<thead>
<tr>
<th>M</th>
<th>T</th>
<th>W</th>
<th>T</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>intro + survey: 1:15 Pablo 1:35 Beccy</td>
<td>31</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>2-2:30 Pablo #1 2:30-3 Beccy #1</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>12</td>
<td>13</td>
<td>2-2:30 Pablo #4 2:30-3 Beccy #3</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>19</td>
<td>20</td>
<td>2-3 Pablo (Finches) Beccy discusses history</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>26</td>
<td>27</td>
<td>2-3 Beccy (Finches) Pablo discusses history</td>
<td>28</td>
<td>29</td>
</tr>
</tbody>
</table>

## October-November

<table>
<thead>
<tr>
<th>M</th>
<th>T</th>
<th>W</th>
<th>T</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4</td>
<td>Beccy: 2-3 Lamarck’s theory of evolution</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
<td>2-3 Controversy Today: jigsaw (JOINT)</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>17</td>
<td>18</td>
<td>9-10:30 Visit from Larry Wakeford (re: Galapagos trip)</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>24</td>
<td>25</td>
<td></td>
<td>26</td>
<td>27</td>
</tr>
<tr>
<td>31</td>
<td>1</td>
<td></td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Final Portfolios Due

August- September

October-November

Final Portfolios Due
Step in/Step out activity to kickoff biology class:

1. I was born in the summertime
2. I have ridden on a motorcycle or motorscooter
3. I’ve seen a fossil
4. I’ve had a pet
5. I ask lots of questions (out loud or in my head)
6. I like to build things/do things with my hands
7. I enjoy being creative
8. I like solving problems
9. I like to cook (with a recipe/without)
10. I’m interested in people
11. I like food
12. I like to write
13. Sometimes I like to be quiet and just watch

These are some of the things that scientists do…you are all, whether you know it or not, already scientists.
Welcome to Science! Please answer the questions below. If there is a word or a question that doesn’t make sense to you, please ask!

Name you like to be called: __________________________________________

Date of Birth: ______________ Place of Birth: ________________________

Email:_______________________   Phone Number: ______________________

Parents’ or Guardians’ names:_________________________________________

Do you have any pets?  What kinds? ___________________________________

Who would you like me to tell when you do something especially well? ________
   ___________________________________________________________________

Please draw a picture of yourself here:

What language do you speak at home? _________________________________

What was the first language you learned? ______________________________

What school did you go to last year? _________________________________

What do you like to do outside of school? ______________________________

What would you really like to learn about in this science class? _____________
   ___________________________________________________________________
   ___________________________________________________________________

Do you know any scientists? Who?_______________________________________
   ___________________________________________________________________
   ___________________________________________________________________
Have you ever taken a science class? Yes No

<table>
<thead>
<tr>
<th>When?</th>
<th>What kind of science?</th>
<th>How was the class?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Have you ever done a science lab? _______ How many? ____________

Have you ever done a science experiment? ____________________________________________

Have you ever had a really good or really bad experience with science or in a science class? Please explain. _________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Is there something specific that excites you about science? ________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Is there anything else that you would like me to know? ________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

What is biology? ________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

What is evolution? ________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Do you have any questions for me? ________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
<table>
<thead>
<tr>
<th>DATE 9/6/05</th>
<th>\textit{Lesson topic(s) and/or Essential Question(s)}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What is science?</td>
</tr>
<tr>
<td></td>
<td>How is scientific truth made?</td>
</tr>
<tr>
<td></td>
<td>How can we represent information in multiple ways?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standards</th>
<th>\textit{What standards will be addressed by this lesson? (The standards are taken from the Met’s Empirical Reasoning subquestions)}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>How will I collect the information?</td>
</tr>
<tr>
<td></td>
<td>What are the results of my research?</td>
</tr>
<tr>
<td></td>
<td>How will I present my results?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Objectives</th>
<th>\textit{What will your students know and be able to do as a result of this lesson?}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Know:</td>
</tr>
<tr>
<td></td>
<td>What a bar graph is.</td>
</tr>
<tr>
<td></td>
<td>That the data collected from a multiple-choice survey can be easily made into a bar graph.</td>
</tr>
<tr>
<td></td>
<td>That the same information can be represented in multiple ways.</td>
</tr>
<tr>
<td></td>
<td>Do:</td>
</tr>
<tr>
<td></td>
<td>Read a bar graph.</td>
</tr>
<tr>
<td></td>
<td>Represent the same raw data in multiple ways.</td>
</tr>
<tr>
<td></td>
<td>Start thinking about their own beliefs and understandings of science.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instructional materials and resources</th>
<th>\textit{What materials, texts, manipulatives, visuals, etc. will you need for this lesson? What technological resources (if any) will you need?}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• 20 copies of the survey</td>
</tr>
<tr>
<td></td>
<td>• 64 post-it notes (four per student, plus advisor)</td>
</tr>
<tr>
<td></td>
<td>• four large pieces of newsprint, each with one survey question at the top and the four survey choices across the bottom.</td>
</tr>
<tr>
<td></td>
<td>• Large markers, pens, and printer paper.</td>
</tr>
</tbody>
</table>
| **Learner Factors** | How does this lesson accommodate different development levels of students? How does this lesson accommodate individual differences in approaches to learning, create connections between the subject matter and student experiences, and or include provisions for students with particular learning differences or needs?  
Kinesthetic learners will benefit from the opportunity to stand up and physically turn their answers into part of a bar graph. Students will be encouraged to ask questions if there is a word or part of the survey they don’t understand. We will work individually, then as a whole class, then in groups of three, so students who aren’t comfortable speaking up and participating in the large group will have a lot of time to work in their comfort zone. |
| **Environmental Factors** | What student grouping will be used? What changes will you need to make in the classroom due to instruction, materials, safety, etc., if any?  
The class is a mix of seventh and ninth graders, and I will be sure to place one seventh grader and one ninth grader in each group of three. Having students work together across grades will allow some older students to emerge as leaders and those who have less experience with graphing and science will learn from those with more. |
| **Instructional activities and tasks** | What activities will you and your students do and how are they connected to the objectives?  
See next page |
| **Assessment activities** | How will you determine what the students know and are able to do during and as a result of the lesson?  
I have prepared an arc of questions to see how much of the theory of graphing students are able to grasp. Our wrap-up activity (in groups of three) requires students to read our collected data from the graphs and represent it in a different way. |
<table>
<thead>
<tr>
<th>Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>How did the lesson plan work? What was effective? What would you change for tomorrow or the next time you use this plan?</td>
</tr>
</tbody>
</table>

When I taught the lesson the first time, I went slightly over the allotted 30 minutes. I need to get better at predicting how long a lesson will take and at keeping an eye on the clock. I also have to get into the classroom a few minutes early so that I can set the lesson up without taking time away from the class.

The 5-10 minutes of me asking questions (what kind of graph is this?, etc…) dragged with this group of students. Before teaching it again, I’d like to work on the arc of questions I ask and maybe get the kids warmed up a bit as well. In contrast, the last ten minutes (listing other kinds of graphs and students working on their own graphs) went by two quickly. I ended up going over the allocated time and just barely got the kids to hang their finished graphs up. We didn’t have time to ‘carousel’ and look at each others’ work, so I asked them to make sure to come up and look at the different graphs over the coming week.

I forgot to write the ‘exit ticket’ up on the board or flip chart, and have to reorganize to do that in the future. It’s hard for some students, especially those who might process aural information more slowly, to remember the prompt long enough to write it down and respond to it.

Teaching again with the second class ran more smoothly. I was able to get them moving more quickly with the questioning part of the lesson and we barely finished again, without time to carousel.

I would do this as a 45 minute class next time and have students spend more time on their graphs in groups, or even take a full hour, with time to critique each others’ graphs and maybe make a second graph.
<table>
<thead>
<tr>
<th><strong>Instructional tasks and activities</strong></th>
<th><strong>What activities will you and your students do and how are they connected to the objectives?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What will you be doing?</strong></td>
<td><strong>What will the students be doing?</strong></td>
</tr>
<tr>
<td>Please take your science folders and a pen and paper out.</td>
<td>Getting their science folders and a pen and paper ready.</td>
</tr>
<tr>
<td>Hanging the four charts on the walls and sticking four post-it notes on the back of each survey.</td>
<td>Sitting down with folder, pen, and paper.</td>
</tr>
<tr>
<td>0:00 Whenever we start science class, I’d like you all to have your science folder and a pen and paper out before we begin. I’ll ask your advisor to remind you before I come down what time I’m coming and that you need to be prepared.</td>
<td>Raising hands.</td>
</tr>
<tr>
<td>1:00 We are going to start the day today by filling out another questionnaire, but this one is in the form of a multiple-choice survey. How many people have taken a multiple-choice survey or test before?</td>
<td>Reading out loud (one student) or else listening while looking at the survey.</td>
</tr>
<tr>
<td>Great. (BEGIN HANDING OUT SURVEY)...this survey has four choices you can choose from. Can someone read the four choices out loud?</td>
<td></td>
</tr>
<tr>
<td>2:00 For each question, please circle one answer. Ready?</td>
<td></td>
</tr>
</tbody>
</table>
You have two minutes. Go.

4:00 Please put your pens down.

Did anyone notice something interesting on the walls today? What is it?

Did anyone notice something on the back of your survey?

That's right, post-it notes. You should each have four post-it notes, one for each question that you answered on the survey.

Each post-it note is like a vote that you get to put on one of the questions on the wall.

You are going to put one post-it note on each chart on the wall, based on your answer on the survey.

If you answered “not sure” for question one (SHOW IT ON THE WALL), put a post-it note right above “not sure” on this question. If someone already put a post-it note there, just put yours right above it.

6:00 Ready? Begin.

8:00 When you are finished, please take a seat and take out a pen and paper.

Filling out survey.
Putting down their pens.

Noticing the charts on the walls.

Noticing post-it notes.

Standing up, moving around the room, putting one post-it note on each chart, based on their answer on the survey.

Taking out pen and paper and sitting back in their seats.
10:00 Everyone please take a seat so we can all look at what we’ve created together. Please put your name and the date at the top of a piece of blank paper. If you see something you didn’t know before, or that you haven’t seen in quite this way before, make a note of it. At the end of the class, put the notes in your science folder.

**What kind of graph is this? (a bar graph)**

**Where are the bars?**

**What are the axes?** ($x = \text{answer}, y = \text{number of students}$)

**What does this graph tell us?** (how many students had each answer)

**Does the graph represent just one student’s opinion? The whole school’s?**

**What is interesting about *this* graph? What stands out?**
Is this what you would expect this graph to look like or is there something unexpected?

How is this graph different from that one? What is useful about a bar graph for representing this information?

18:00 What are some other kinds of graphs and ways of representing information?
   • make a list: choice...number who chose it
   • write a paragraph
   • draw a pie graph
   • calculate fractions or percentages
   • draw stick figure people

These are all ways that we could represent the information in our graphs.

20:00 KARA!!!! ARE THERE MORE THAN FIVE MINUTES LEFT? IF NOT, JUST CREATE ONE POSSIBILITY AS A CLASS, THEN SKIP TO
EXIT TICKET.
Have students volunteer to be in each group, in this order:
- percentage or fractions
- pie graph
- paragraph
- list
- stick figures

Try to mix 9th and 11th graders together.

Give each group of three a fresh piece of paper, and specify which graph everyone will be representing.

Circulate from group to group to answer questions and offer assistance.

Have groups all hang their representations around the room and have everyone carousel to look at each one.

If there are less than five minutes left, move straight to the exit ticket activity:

28:00 What is one thing you learned today that you didn’t know before?
<table>
<thead>
<tr>
<th>Collect the charts while students are writing and take the exit tickets at the end.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thanks and see you all tomorrow!</strong></td>
</tr>
</tbody>
</table>

Revised 1/2003
Please circle your answer to each of the four questions below.

1. Scientists follow the scientific method: hypothesis, experimentation, observation, analysis, conclusion
   - Disagree.  
   - Not Sure.  
   - Sometimes True.  
   - Always true.

2. Science and religion are at odds.
   - Disagree.  
   - Not Sure.  
   - Sometimes True.  
   - Always true.

3. A scientific theory is simply a guess about how the world works.
   - Disagree.  
   - Not Sure.  
   - Sometimes True.  
   - Always true.

4. Scientists wear white coats and work inside a laboratory.
   - Disagree.  
   - Not Sure.  
   - Sometimes True.  
   - Always true.
<table>
<thead>
<tr>
<th>DATE 9/7/05</th>
<th><strong>Lesson topic(s) and/or Essential Question(s)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observation:</td>
</tr>
<tr>
<td></td>
<td>How is scientific truth made?</td>
</tr>
<tr>
<td></td>
<td>What methods do scientists use?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standards</th>
<th>What standards will be addressed by this lesson? (The standards are taken from the Met’s Empirical Reasoning subquestions)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What information (data) do I need to collect?</td>
</tr>
<tr>
<td></td>
<td>How will I collect the information?</td>
</tr>
<tr>
<td></td>
<td>What conclusions can I draw from my research?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Objectives</th>
<th>What will your students know and be able to do as a result of this lesson?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Know:</td>
</tr>
<tr>
<td></td>
<td>That observation is an important tool that scientists use for making scientific truth.</td>
</tr>
<tr>
<td></td>
<td>Candle flames are more than just an orange blob.</td>
</tr>
<tr>
<td></td>
<td>The five-step scientific method is not followed by most scientists in the way we usually learn about it in school.</td>
</tr>
<tr>
<td></td>
<td>Do:</td>
</tr>
<tr>
<td></td>
<td>Carefully observe a process of change.</td>
</tr>
<tr>
<td></td>
<td>Question their own beliefs and understandings of how science is done.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instructional materials and resources</th>
<th>What materials, texts, manipulatives, visuals, etc. will you need for this lesson? What technological resources (if any) will you need?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• 16 candles</td>
</tr>
<tr>
<td></td>
<td>• modeling clay (to stick candles on table)</td>
</tr>
<tr>
<td></td>
<td>• notecards for exit ticket</td>
</tr>
<tr>
<td></td>
<td>• string, rulers, markers if students want to measure rate of burning.</td>
</tr>
<tr>
<td></td>
<td>• Pencils and markers or colored pencils</td>
</tr>
<tr>
<td></td>
<td>• A bowl of water in case of flame</td>
</tr>
</tbody>
</table>
| **Learner Factors** | How does this lesson accommodate different development levels of students? How does this lesson accommodate individual differences in approaches to learning, create connections between the subject matter and student experiences, and or include provisions for students with particular learning differences or needs?  

The candle observation is designed to engage all students. Some students might be interested in simply looking at the candle and drawing a basic sketch, others might want to measure the rate at which it burns or see how the candle reacts under different conditions. Students will be encouraged to ask questions if there is a word or part of the worksheet they don’t understand. |
| **Environmental Factors** | What student grouping will be used? What changes will you need to make in the classroom due to instruction, materials, safety, etc., if any?  

We will work individually, as a whole class, and in pairs, so that students will have the chance to contribute and show what they know in different size groupings. My largest safety concern is the possibility of a fire in the room. |
| **Instructional activities and tasks** | What activities will you and your students do and how are they connected to the objectives?  

See next page |
| **Assessment activities** | How will you determine what the students know and are able to do during and as a result of the lesson?  

I will move around the room to listen, watch, and ask questions as students work on each part of the worksheet. At the end of class, I will collect the worksheets and an |
exit ticket from each student.

**Reflection**

*How did the lesson plan work? What was effective? What would you change for tomorrow or the next time you use this plan?*

The candle observation lab is consistently well-received by students. My summer students loved it and both Beccy’s and Pablo’s classes were very focused and did some of the best work of the unit in that class period. In Pablo’s class, I didn’t get to the point of discussing observation v. inference in the context of the candle lab. I had hoped that they would be introduced to the concept today, so that the footprint activity tomorrow will reinforce and clarify, rather than introduce the words and idea.

In Beccy’s class, I did make time to discuss observation v. inference and had students figure out which of the questions on their lab worksheets asked them to make observations, and which asked them to make inferences. They then made a key on their worksheets, explaining that the questions with a box around them were inferences and those that were circled were observations.

It will be interesting to see how well each class differentiates between observations and inferences in tomorrow’s footprint activity.
### Instructional tasks and activities

<table>
<thead>
<tr>
<th>What activities will you and your students do and how are they connected to the objectives?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What will you be doing?</strong></td>
</tr>
<tr>
<td>0:00 Hello everyone, how are you all doing today? (If students don’t have their ER folders out, ask them to take them out, plus a pen and paper.)</td>
</tr>
</tbody>
</table>

Today we are doing our first lab. From reading all your questionnaires, I know that many of you have done labs before, but you may not know what other peoples’ experience has been. **Raise your hand if you have done a lab before.**

When we do labs in this class, **we will always begin by discussing the safety procedures.** In this lab, you will be working with an open flame...that’s right, you get to play with fire.

SO:
1. It is extremely important that there is nothing unnecessary on the table during this lab. Please take your ER folder and anything else you have and put it **under your chair.**
2. I will be giving you a piece of paper. Keep it six inches away from the candle.

They love lab safety, I can read it in their eyes.
3. There is water on the table in case something does catch fire. We don’t want to have to use it, but if we do, please know where it is and put the fire out quickly.

At the end of each lab, you will be handing me a **lab report**. The structure of today’s lab report is set up for you already on the sheet I am passing around. (BEGIN TO HAND OUT) You will all complete the lab report during class and hand in to me at the end. I will collect them and make a copy for myself than bring them back for you to place in your ER folders.

3:00 Please be sure to put your name, advisor, and date on the worksheet. Could someone read the introduction?

4:00 IF ANYONE WAS DISRUPTIVE DURING READING, MAKE IT CLEAR THAT MUTUAL RESPECT IS EXPECTED FROM EVERYONE IN THIS CLASSROOM. WHEN WE’RE ALL WORKING TOGETHER AS AN ADVISORY, SOMEONE ELSE IS TALKING, YOU ARE NOT. IF YOU HAVE A QUESTION, SOMEONE ELSE PROBABLY DOES TOO, SO DO US ALL A FAVOR AND ASK OUT LOUD—THAT WAY WE CAN ALL LEARN FROM YOUR QUESTION.

4:30 could someone else read the first paragraph on

---

Noticing where the water is

Getting a copy of the lab report/worksheet

Reading the introduction or listening QUIETLY.
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:00</td>
<td>Are you all ready to observe these candles burning? If you want to draw or describe</td>
</tr>
<tr>
<td></td>
<td>the candle before its lit, you can start that now…Beccy/Pablo and I will come</td>
</tr>
<tr>
<td></td>
<td>around to light the candle for you. For the next five minutes, observe very carefully.</td>
</tr>
<tr>
<td></td>
<td>You MUST use pictures and words to describe what you observe. If you have any specific</td>
</tr>
<tr>
<td></td>
<td>questions about candles and how they burn, there are some supplies in the middle of</td>
</tr>
<tr>
<td></td>
<td>the table that might help you explore further.</td>
</tr>
<tr>
<td></td>
<td>LIGHT CANDLES (make sure they are all stable with paper 6’’ away.</td>
</tr>
<tr>
<td></td>
<td>12:00 When your candle gets close to the clay, please blow it out.</td>
</tr>
<tr>
<td></td>
<td>PUT CANDLES OUT</td>
</tr>
<tr>
<td>12:30</td>
<td>Flip your lab report over and answer the questions in Part II on your own. If you</td>
</tr>
<tr>
<td></td>
<td>have any questions, please ask</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reading out loud/listening.</td>
</tr>
<tr>
<td></td>
<td>Getting candles and clay, sticking the candle in the clay.</td>
</tr>
<tr>
<td></td>
<td>Reading out loud/listening.</td>
</tr>
<tr>
<td></td>
<td>Getting ready/drawing the unlit candles or describing them in words.</td>
</tr>
<tr>
<td></td>
<td>Observing candles, measuring, recording, drawing, etc…</td>
</tr>
</tbody>
</table>
15:00 Some of the questions you just answered asked you to write down an observation. What is an observation?

WRITE ON BIG PAPER!! Ask students to write this somewhere on the lab sheet or another piece of paper.

-not just sight, also smell, touch, taste, etc…
-describe something as you experienced it: saw it, tasted it, heard it, smelled it……

16:30 Other questions you just answered asked you to make an inference. What is an inference?

-a conclusion you come to based on an observation. It is not what you observed, but what you think the observations might mean.

18:00 Go through each question and ask if it is an observation or inference, ask students to circle the observations and put a box around the inferences:

does the candle change while it is burning?
How does it change?
Does the candle appear to move?
Does it seem to be moving on its own?
If not, what is making it move?
Is the candle alive?

20:00 Now turn to a partner to share your observations and answering Part II questions.

Responding with definitions of observation v. inference…

Distinguishing between observations and inferences.
Circling observations, boxing inferences.
inferences. Take a look at your partner’s drawings, writing, and answers to the observations and inferences questions. Compare their observations to your own. Use the chart on your lab report to write some similarities between your observations and some differences.

24:00 FRESH SHEET OF BIG PAPER!

Did anyone find some similarities? What did you find? Some differences? What did you find?

Does everyone observe things in exactly the same way?

Why not?

27:00 The lab report is almost finished, and you’re doing great work. The last piece today is reflecting on what we’ve done in the last 28 minutes. Please write the list down as we go. What are the steps that we took today to do this lab? Try to remember all the things we discussed and use the lab report sheet as a guide.

-safety
-intro/background
-observation
-recording observations and making inferences
-sharing with a partner
-reflecting

Working with a partner to evaluate each others’ work and see that not everyone observes the exact same things in the exact same way.

Sharing partner responses with the group.
29:00 exit ticket: do scientists always use the exact same scientific method when they are doing research?

Revised 1/2003
LABORATORY ACTIVITY ONE: Observing a candle

Introduction
You have probably lit candles many times in your life: for birthdays, holidays, religious events, emergencies, or just for decoration. However, few of us have ever carefully observed a candle as it burns. In this lab activity, you will carefully observe a burning candle to record information about the candle and to generate new questions.

Part I: Observation

You will be provided with a candle and some clay to stick the candle to the table. Take some time to observe the candle carefully before it is lit. I will light the candle for you. There is a bucket of water in the middle of the table in case the candle falls.

As you observe the burning candle, please draw one or more diagrams of the candle, focusing on the flame. Be sure to label the different parts of the diagram and to indicate specific colors, textures, or other aspects of the candle or flame that you notice.

Describe what you see in words:
__________________________________________
__________________________________________
__________________________________________
__________________________________________
__________________________________________
__________________________________________
__________________________________________
__________________________________________
Part II: Questions

Does the candle change while it is burning? _________ How does it change?________
_______________________________________________________________________
_______________________________________________________________________

Does the candle appear to move? ______ Does it seem to be moving on its own? ______
If not, what is making it move?______________________________________________
_______________________________________________________________________

Is the candle alive? _______________________________________________________

Part III: Partner Share

Compare your drawing of the candle and your written description to your partner’s. Is there anything that you described in the same way? Is there something your partner observed that you didn’t observe? Record any similarities and differences below.

<table>
<thead>
<tr>
<th>SIMILARITIES</th>
<th>DIFFERENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

With your partner, think of one or two questions you have about candles, flames, etc.

Our Question(s): ___________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________

Part IV: Reflection

What skills and methods did you use today that scientists use? _________________
_______________________________________________________________________
_______________________________________________________________________
**DATE 9/14/05**

**Lesson topic(s) and/or Essential Question(s)**

Observation v. Inference
What is a theory?
How is the term used in science v. outside science?

**Standards**

*What standards will be addressed by this lesson? (The standards are taken from the Met’s Empirical Reasoning subquestions)*

What are the results of my research?
What conclusions can I draw from my research?

**Objectives**

*What will your students know and be able to do as a result of this lesson?*

**Know:**
The difference between an observation and inference
How the word “theory” is defined in science and outside of science

**Do:**
Make and distinguish between observations and inferences.
Use a dictionary, science textbook, or internet to find definitions.
Distinguish between a scientific and non-scientific definition of “theory”.
Site a source (website or text) for a simple quotation.

**Instructional materials and resources**

*What materials, texts, manipulatives, visuals, etc. will you need for this lesson? What technological resources (if any) will you need?*

Students will need access to the internet.
I will provide multiple textbooks, teaching materials, and other science books.
Dictionaries.
| **Learner Factors** | How does this lesson accommodate different development levels of students? How does this lesson accommodate individual differences in approaches to learning, create connections between the subject matter and student experiences, and or include provisions for students with particular learning differences or needs?  

Students have the option of looking for information in a variety of places. More advanced students who are comfortable with biology textbooks and web browsing might be interested in how teachers are taught to teach science, and can get definitions from the teaching materials. |
| **Environmental Factors** | What student grouping will be used? What changes will you need to make in the classroom due to instruction, materials, safety, etc., if any?  

We will work as a large group, then individually, then come back together at the end. |
| **Instructional activities and tasks** | What activities will you and your students do and how are they connected to the objectives?  

See next page |
| **Assessment activities** | How will you determine what the students know and are able to do during and as a result of the lesson?  

The full group time at the start and end of the lesson will give me the opportunity to evaluate students’ understanding of observation v. inference and scientific theory v. theory outside of science by listening to their responses, engaging and correcting misunderstandings, |
and asking specific students for a response as needed.

**Reflection**

*How did the lesson plan work? What was effective? What would you change for tomorrow or the next time you use this plan?*

I taught this lesson for thirty minutes in Pablo’s class then went immediately next door to Beccy’s. I went over by about 3 minutes in Pablo’s class, which meant 5 minutes less for Beccy’s.

All in all, the lesson felt good today. Beccy’s students got more excited and into the inferences as we went on. It seems like they have a very different understanding with their advisories—my method (hand-raising v. calling out, demanding silence v. letting noise continue, discussing respect…) is in the middle of their two approaches: a little bit stricter than one advisor’s and a bit looser than the other’s.

The footprints activity was very effective. I got better in Beccy’s advisory (the second class) at figuring out individual students’ mis/understandings. The theory activity was too rushed at the end and I will need to give it more time if I teach it again. They need ten minutes or more to put up their answers and discuss where they should go on the chart. I also should have had students write their names up on the cards with their definitions, so that putting them up would be a built-in public assessment for individual students, not just the whole class.

Next time, I want to use two definitions of theory, rather than “in science” v. “outside of science.” I realized part way through the class that I was reifying the very boundaries that I wanted to be tearing down by incorporating science studies into the curriculum.

Or maybe this shouldn’t be a constructivist activity at all, with students creating knowledge collectively…instead, it might be an appropriate topic to do a direct presentation...
on. Or maybe some combination.
<table>
<thead>
<tr>
<th><strong>Instructional tasks and activities</strong></th>
<th><strong>What activities will you and your students do and how are they connected to the objectives?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What will you be doing?</strong></td>
<td><strong>What will the students be doing?</strong></td>
</tr>
<tr>
<td>0:00 With Beccy’s class:</td>
<td>Remembering our last class</td>
</tr>
<tr>
<td>Last week we talked about observations and inferences. Let’s write the definition of observation and inference so we can refer back to it today:</td>
<td>Writing down definitions</td>
</tr>
<tr>
<td><strong>Observation</strong> = <strong>Getting information with any of the five senses (sight, touch, taste, sound, smell).</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Inference</strong> = <strong>A conclusion based on your observations (and maybe some outside knowledge/information)</strong></td>
<td></td>
</tr>
<tr>
<td>With Pablo’s class:</td>
<td>Writing definition</td>
</tr>
<tr>
<td>Last week we all observed a candle. Let’s write a formal definition of what observation is to refer back to today:</td>
<td></td>
</tr>
<tr>
<td><strong>Observation</strong> = <strong>Getting information with any of the five senses (sight, touch, taste, sound, smell).</strong></td>
<td></td>
</tr>
<tr>
<td>Who remembers answering questions about your observation? One of the questions you answered was “does the candle appear to be moving?” could you answer this simply by observing?</td>
<td>Responding: yes/no/not sure</td>
</tr>
<tr>
<td>Another question you answered was “is the candle alive?”</td>
<td></td>
</tr>
</tbody>
</table>
could you answer this simply by observing or do you have to draw a conclusion based on your observations and some outside knowledge?

That’s called inference. I’m going to write a formal definition of inference that we will also refer back to today.

**Inference = A conclusion based on your observations (and maybe some outside knowledge/information)**

4:00
With both classes:

1. show first segment of two sets of footprints,

What are we looking at? ask students to come with as many observations about the prints as possible, and to make inferences from them. (distinguish between the two as each statement is offered), on a chart:

<table>
<thead>
<tr>
<th>Observations</th>
<th>Inferences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>2. show the second segment, ask for observations and inferences</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td></td>
</tr>
<tr>
<td>3. show the third segment, ask for observations and inferences</td>
<td></td>
</tr>
<tr>
<td>If there is time, ask:</td>
<td></td>
</tr>
<tr>
<td>4. how do we know what we know? what are alternate possibilities we still haven’t thought of?</td>
<td></td>
</tr>
<tr>
<td>If no time,</td>
<td></td>
</tr>
<tr>
<td>Great, we will be making many more observations and inferences as we go, try to keep the difference between the two in your head during science.</td>
<td></td>
</tr>
<tr>
<td>10:00 Tear off to a clean sheet of paper. Now we’re going to move on to some different definitions, but this time you’re going to provide the definitions, from your own brain, from the internet, and from the books on the table.</td>
<td></td>
</tr>
<tr>
<td>The word we are going to define is THEORY. This may seem like a simple word but it is a very important word in science and the word is used differently in science and outside of science.</td>
<td></td>
</tr>
<tr>
<td>Observing footprints and sharing their observations and making inferences, distinguishing between the two.</td>
<td></td>
</tr>
<tr>
<td>Observing footprints and sharing their observations and making inferences, distinguishing between the two.</td>
<td></td>
</tr>
<tr>
<td>Coming up with additional possibilities.</td>
<td></td>
</tr>
</tbody>
</table>
I’m passing around a stack of large note cards. Please take one note card.

Some of the books on the table are… (show books)

You have seven minutes to find a definition and write it on a note card. Make sure that you also write where the definition came from. I will put an example of how to cite your source on the flip chart.

You may begin.

(website, text (title and author or publisher), or your name)

also make sticky tape pieces for hanging while students work. Roam room and offer help, ask advisors and Corey and Nely to work with students that might need extra help.

20:00
Please finish writing your definitions and come back to the table so we can wrap up.

Our goal is to distinguish between the definition of “theory” in science and definitions outside of science.
Make chart:

<table>
<thead>
<tr>
<th>Theory in science</th>
<th>Theory outside science</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Who thinks they have a definition that is definitely a scientific one?  
Read aloud, ask students “do you agree that this is a definition of theory as it is used in science?”  
Place on chart with tape.

Who thinks they have a definition that is definitely not a scientific one?  
Read aloud, ask students “do you agree that this is a definition of theory as it is used outside of science?”  
Place on chart with tape.

Ask students to offer their definitions, they can read them aloud and have the class come to consensus or vote on where the definition should go...some might go in the middle or a ? area.

Exit ticket (or if out of time, just pose the question:)

**In science, is a theory simply a guess about how the world works?**

Offering a definition or analyzing whether it is the definition used in science or outside science.

Offering a definition or analyzing whether it is the definition used in science or outside science.

Reading their definitions aloud and determining whether they are the definitions used in science or outside science.

Responding verbally or in writing to exit prompt.
<table>
<thead>
<tr>
<th>DATE 9/14/05</th>
<th>Lesson topic(s) and/or Essential Question(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What is a theory?</td>
</tr>
<tr>
<td></td>
<td>How is the term used in science V. outside science?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standards</th>
<th>What standards will be addressed by this lesson? (The standards are taken from the Met’s Empirical Reasoning subquestions)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What is my hypothesis? How can I test it?</td>
</tr>
<tr>
<td></td>
<td>What are the results of my research?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Objectives</th>
<th>What will your students know and be able to do as a result of this lesson?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Know:</td>
<td>How the word “theory” is defined in science and outside of science</td>
</tr>
<tr>
<td></td>
<td>What a hypothesis is.</td>
</tr>
<tr>
<td></td>
<td>Begin to understand the mechanism of natural selection.</td>
</tr>
<tr>
<td>Do:</td>
<td>Distinguish between a scientific and non-scientific definition of “theory”.</td>
</tr>
<tr>
<td></td>
<td>Analyze pictorial data and create testable hypotheses from it.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instructional materials and resources</th>
<th>What materials, texts, manipulatives, visuals, etc. will you need for this lesson? What technological resources (if any) will you need?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I will bring back the “theory” definitions sheet from yesterday and the consensogram graph of student understanding of theory in science.</td>
</tr>
<tr>
<td></td>
<td>The roach problem data sheet.</td>
</tr>
<tr>
<td></td>
<td>Note cards for exit ticket.</td>
</tr>
</tbody>
</table>
| **Learner Factors** | How does this lesson accommodate different development levels of students? How does this lesson accommodate individual differences in approaches to learning, create connections between the subject matter and student experiences, and or include provisions for students with particular learning differences or needs?  
Student are given the option of going on to make a graph if they finish the independent work quickly. I hope that pairing students to come up with hypotheses will allow them to share their strengths and help each other make sense of the data and understand what a hypothesis should look like. |
| --- | --- |
| **Environmental Factors** | What student grouping will be used? What changes will you need to make in the classroom due to instruction, materials, safety, etc., if any?  
Working as a whole group, then individually, then in pairs, then coming back together to wrap up. |
| **Instructional activities and tasks** | What activities will you and your students do and how are they connected to the objectives?  
See next page |
| **Assessment activities** | How will you determine what the students know and are able to do during and as a result of the lesson?  
I will collect their cockroach worksheets at the end of class and will try to ask questions to gauge understanding throughout the class. |
## Reflection

*How did the lesson plan work? What was effective? What would you change for tomorrow or the next time you use this plan?*

I realized today that defining words without first doing something with them doesn’t work for a lot of students. I began Beccy’s class by hanging the theory definitions chart again and explaining what a theory is in science v. outside of science. It would probably be better to *integrate* the misconception I’m trying to address into the day’s lesson, rather than just trying to explain it away.

Perhaps the concept of ‘a theory’ shouldn’t be introduced until I am introducing a specific theory, i.e. the theory of evolution. Once we are talking about and working with the theory of evolution, we could take a step back and ask: so what is a theory anyway?

Judith, a fellow MAT student, came to observe the class and offered some additional feedback: rather than starting with the definitions, I could begin by looking at the evidence for evolution v. for intelligent design, then bring up the concept of theory and what it means.

With Pablo’s class, I eliminated the whole theory-defining introduction and instead, used the cockroach lab as a hook into understanding how to develop a hypothesis.

I realized even more today that the theory activity was trying to force a dichotomy down their throats that I myself don’t want to support. In actuality, scientists use both definitions of theory, one is the common use or a “working theory” (used interchangeably with “working hypothesis”, according to Judith) and the other is “the theory of x.”

I need to rethink the purpose of defining theory before teaching the lesson again. Maybe they need to understand and DO hypotheses before theory.

Revised 6/2004
<table>
<thead>
<tr>
<th><strong>Instructional tasks and activities</strong></th>
<th><strong>What activities will you and your students do and how are they connected to the objectives?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What will you be doing?</strong></td>
<td><strong>What will the students be doing?</strong></td>
</tr>
<tr>
<td>Prep work:</td>
<td>Getting ER folders and paper and pens out.</td>
</tr>
<tr>
<td>Hang theory chart and consensogram graph.</td>
<td></td>
</tr>
<tr>
<td>0:00-5:00 clarifying the definitions of “theory” in science and outside science.</td>
<td>Reviewing the work we did yesterday and fitting their definition into the two I am offering.</td>
</tr>
<tr>
<td>In science:</td>
<td></td>
</tr>
<tr>
<td>A theory is an organized model based on data from many tested hypotheses.</td>
<td></td>
</tr>
<tr>
<td>Outside of science:</td>
<td></td>
</tr>
<tr>
<td>A theory is a guess.</td>
<td></td>
</tr>
<tr>
<td>5:00-10:00 pass out and introduce the cockroach mystery.</td>
<td></td>
</tr>
<tr>
<td>(see attached)</td>
<td></td>
</tr>
<tr>
<td>Ask students to read the lab safety, introduction, and story out loud, then give them time to work individually to turn the pictorial data into numerical data and record it on the chart.</td>
<td>Listening quietly or reading aloud.</td>
</tr>
<tr>
<td></td>
<td>Counting roaches and transforming data into a chart.</td>
</tr>
</tbody>
</table>
10:00-15:00 what is a hypothesis?

One definition of theory that we put up on the chart yesterday was “an educated guess.” As we discussed earlier, a theory in science is not a guess at all. It is supported by many many guesses that have all been tested in some way. A guess is something we are still waiting for proof of. A scientific theory has already been tested many many times by many different people and all of the tests have agreed with the theory.

But…”an educated guess” is a definition that is often used for another important part of science: a hypothesis.

WRITE AND HAVE STUDENTS WRITE:
A hypothesis is an “educated guess” (what does that mean? It is the result of some knowledge and some observations, like an inference) that can be tested.

15:00-20:00 students work with a partner to come up with a hypothesis.

20:00-25:00 share several hypotheses.

25:00-30:00 this did not really happen, but the data was

Taking notes.

WRITING.

Working in pairs to come up with a hypothesis.

Sharing hypotheses with the whole class.
created to suggest that a specific process is occurring here: each generation of cockroaches is more resistant to the poison.

In generation one, some can survive poison, but most cannot and they die.

The children of the ones that survived are sprayed with poison and a bunch of them survive.

Then the children of those survivors are sprayed and even more of them survive.

Finally, the great great grandroaches of the original survivors are sprayed and they all can survive the poison.

Each time the poison was sprayed, all the roaches that could resist the poison lived and they passed this ability to resist the poison on to their children. Eventually, the entire population of roaches were all poison survivors.

This process is called **natural selection** (some people say “survival of the fittest”) and we’ll be talking about it a lot more in the coming weeks.

Exit ticket:
What is one question you have about natural selection?
LABORATORY ACTIVITY TWO: The Cockroach Mystery

LAB SAFETY
Unless you are a roach, there are no special safety precautions for this lab.

Introduction
Cockroaches are often an unfortunate reality of living in a house. You may have seen them, killed them, or even eaten them before (they’re quite good fried!), and yes, there are some living in Beccy’s advisory. In this lab activity, you will be asked to analyze data: first observe the data and then draw some conclusions based on your observations of the data. Later on, you will come up with a full hypothesis to explain the data.

Part I: The Story
Pablo is having a problem in the bathroom. Every morning when he goes in to take a shower, the bathtub is full of roaches. So he buys some poison and sprinkles it all over the tub. Almost all of the roaches die instantly and he figures that the few that have survived will die from the poison in the next few days. A week later, when he looks in the bathtub expecting them all to be dead, he sees that there are more roaches alive than there were right after spreading the poison. Pablo decided to use the poison again and this time, like last time, most of the roaches died right away. But this time, a bunch of roaches didn’t die. Pablo figured they would die in a few days so he left them in the tub with the poison. When he came back for the third week, expecting them all to be dead, he found that even more roaches were alive than when he left. So he used the poison again, but most of the roaches didn’t die. He hoped for the best and left them in the tub. A week later, he came back and much to his disappointment, the tub was full of roaches, even more than he’d started with. Pablo is desperate to find out what’s going wrong here so he begged me to have you analyze the data and offer some hypotheses. Why has the poison stopped working?

Part II: Collecting Data
Carefully observe the data below. You are looking at pictures of the roach population each week before and after being sprayed with poison. To analyze the data, please translate it from pictorial into numerical form.

Week one

+ poison →
Week two

+ poison

Week three

+ poison

Week four

+ poison

Part III: Charting data

Fill the numerical data you’ve collected into the chart below. If you have extra time, you can try to graph the data in whatever way seems most appropriate.

<table>
<thead>
<tr>
<th></th>
<th>Week one</th>
<th>Week two</th>
<th>Week three</th>
<th>Week four</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before poison</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After poison</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Part IV: Developing a hypothesis:

Based on what you have observed and on what you know about living things, what is one testable hypothesis to explain why the poison has stopped working?

________________________

________________________

________________________
<table>
<thead>
<tr>
<th>DATE 9/21/05</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lesson topic(s) and/or Essential Question(s)</strong></td>
</tr>
<tr>
<td>Evolution by Natural Selection</td>
</tr>
<tr>
<td>Darwin’s finches</td>
</tr>
<tr>
<td>How can we model a process that happens in nature?</td>
</tr>
<tr>
<td>How can we gather, represent, and interpret data?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What standards will be addressed by this lesson?</strong> <em>(The standards are taken from the Met’s Empirical Reasoning subquestions)</em></td>
</tr>
<tr>
<td>What idea do I want to test?</td>
</tr>
<tr>
<td>What is my hypothesis? How can I test it?</td>
</tr>
<tr>
<td>What information (data) do I need to collect?</td>
</tr>
<tr>
<td>How will I collect the information?</td>
</tr>
<tr>
<td>What are the results of my research?</td>
</tr>
<tr>
<td>How will I present my results?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What will your students know and be able to do as a result of this lesson?</strong></td>
</tr>
<tr>
<td>Know:</td>
</tr>
<tr>
<td>Darwin’s observations on the H.M.S. Beagle, combined with other ideas and evidence, eventually led him to his theory of evolution by natural selection (“descent with modification”).</td>
</tr>
<tr>
<td>Different species adapt to specific environments over generations.</td>
</tr>
<tr>
<td>Do:</td>
</tr>
<tr>
<td>Determine how to collect data from 15 student researchers.</td>
</tr>
<tr>
<td>Determine how to represent collected data.</td>
</tr>
<tr>
<td>Use an experimental model with actual biological data to formulate hypotheses.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instructional materials and resources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What materials, texts, manipulatives, visuals, etc. will you need for this lesson? What technological resources (if any) will you need?</strong></td>
</tr>
</tbody>
</table>
| 5 forks  
| 5 spoons  
| rice (uncooked basmati)  
| carrots in long strips  
| two large pieces of paper  
| markers for student researchers  
| map of the Galapagos  
| finch heads with information on back.  

**Learner Factors**

*How does this lesson accommodate different development levels of students? How does this lesson accommodate individual differences in approaches to learning, create connections between the subject matter and student experiences, and or include provisions for students with particular learning differences or needs?*

The lesson is partly physical, kinesthetic lab, partly mathematical analysis, partly graphical representation, and partly thinking in larger abstract models and hypothetical situations. I hope that the problem of needing to represent the data in a useful way will help students think about ways to present information in their final experiment and in their exhibitions.

**Environmental Factors**

*What student grouping will be used? What changes will you need to make in the classroom due to instruction, materials, safety, etc., if any?*

Students will be assigned to a team and/or assigned a specific role in the first activity. I will assign groups of three for the second activity.

**Instructional activities and tasks**

*What activities will you and your students do and how are they connected to the objectives?*

*See next page*

**Assessment activities**

*How will you determine what the students know and are able to do during and as a result of the lesson?*

I will be assessing the class’ ability to work together to solve a problem and then their work in small groups. I’ll ask questions to see if students understand the basic concepts, then to see if they are able to apply them to
different situations. The work they do of grouping finches and then explaining how there are different species on different islands will help me to determine how well they understand natural selection.

<table>
<thead>
<tr>
<th>Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>How did the lesson plan work? What was effective? What would you change for tomorrow or the next time you use this plan?</em></td>
</tr>
</tbody>
</table>

The whole silence thing doesn’t really work with this class—it is much more difficult to get students to listen and do what I want when they are outside and I do NOT like raising my voice.

The outside part of the class was a lot of fun and I think that the indoor analysis part of the class was pretty effective. Students actually talked to each other and the most rewarding part of the class was sitting with individual groups of students and talking about their ideas for how to model the finch situation.

I want to get better at creating opportunities for positive, productive group work, where I will have the chance to listen, ask questions, and move around the room as they stay focused.

Revised 6/2004
<table>
<thead>
<tr>
<th><strong>Instructional tasks and activities</strong></th>
<th><strong>What activities will you and your students do and how are they connected to the objectives?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What will you be doing?</strong></td>
<td><strong>What will the students be doing?</strong></td>
</tr>
<tr>
<td>Prep: scatter rice and carrot pieces on the ground outside of the school*; hang two large pieces of paper on a wall outside (bring them inside if students seem too distracted outside)</td>
<td>Walking outside with a pen and paper.</td>
</tr>
<tr>
<td>* in case of inclement weather, set up on lunch room floor 2:00 Everyone grab a pen and paper, we’re going outside.</td>
<td>Silently getting into groups based on the words on their backs.</td>
</tr>
<tr>
<td>2:03 Place assignments on students’ backs and tell them to get into groups without using any words:</td>
<td></td>
</tr>
<tr>
<td><strong>Timekeeper</strong></td>
<td></td>
</tr>
<tr>
<td>You are in charge of the collection contest. If you don’t have a watch, please get one from an advisor or student. You can decide where the competitors stand before the competition begins. You tell the competitors when to begin and after thirty seconds, tell them to stop.</td>
<td></td>
</tr>
<tr>
<td><strong>Collector</strong></td>
<td></td>
</tr>
<tr>
<td>You must work with the other collector to gather the data from the competition. Please record the data in whatever way you choose on one of the large pieces of paper so that everyone can see it.</td>
<td></td>
</tr>
<tr>
<td><strong>Representer</strong></td>
<td></td>
</tr>
<tr>
<td>Your task is to take the “raw” data that the collectors have</td>
<td></td>
</tr>
</tbody>
</table>
gathered and to translate it into whatever form you think will be the most valuable. You can use any type of chart or graph, including those we’ve worked on this year: pie chart, bar graph, line graph, percentage or fractions, etc. Please use one of the large pieces of paper so that we can all see your representation of the data.

**Interpreter**
It is your job to guide the class through an analysis of the data as the representers have chosen to represent it. What can we learn from the data? Is anything different from what you expected? You can ask more questions of your choosing.

**Team FORK competitor**
You are an esteemed member of Team FORK. Please listen carefully to the timekeeper and carefully follow his/her directions and the instructions below: when the timekeeper says you may begin, you must try to collect as much food as you can by using ONLY the fork in your right hand. When you pick up a piece of food, transfer it into your left hand and hold it there. You must stop IMMEDIATELY when the timekeeper tells you to stop. After you are finished, please go silently to the data collectors and open your left hand, presenting them with the food you have collected.

**Team SPOON competitor**
You are an esteemed member of Team SPOON. Please
listen carefully to the timekeeper and carefully follow his/her directions and the instructions below: when the timekeeper says you may begin, you must try to collect as much food as you can by using ONLY the spoon in your right hand. When you pick up a piece of food, transfer it into your left hand and hold it there. You must stop IMMEDIATELY when the timekeeper tells you to stop. After you are finished, please go silently to the data collectors and open your left hand, presenting them with the food you have collected.

2:10 Once students are in groups, tell them they can take the paper off their backs and read their job descriptions.

2:12 Ask students to read aloud with their partner or in their group.

2:15 If anyone has any questions, please ask them now.

2:17 Timekeeper, it’s all yours.

2:17-2:20 contest

2:20-2:25 data collection

Taking their names and instructions off their backs and reading them.

Reading instructions out loud with their partner.

Asking any clarifying questions about their job.

Timekeeper will run the contest.

Competitors will present their collected food to the data collectors.

Data collectors will record how much of each type of food
2:25-2:35 representation and analysis

2:35 return to classroom for finches activity

2:40 pass out lab sheet, finch species chart, and map of the Galapagos.
Assign groups of three that are different from where they are sitting.

Let’s read the introduction out loud together.

In the 1830s, a boat called the H.M.S. Beagle left England to travel around the world. The naturalist on the boat was a man named Charles Darwin. Among the stops that this boat made was a couple of weeks on the Galapagos Islands, off the coast of Ecuador. You have a map of the islands in front of you, as well as a chart of some of the famous inhabitants of the islands: a type of bird known as finches.

Part One: There is a lot that all these different species of finches have in common: they mostly have similar coloration, are a similar size, and have a very similar bone structure. From looking at this chart, can you figure out what is so unique about each species of finch?

1. James Island has mostly seed plants with small seeds was collected by the competitors.

Representers will make a chart or several charts to show what was collected. Interpreter will lead the class through a series of questions to understand what has happened.

Walking back to the classroom.

Reading the background/introduction out loud.

Answering the sheet with partners and help from Kara and Advisors.
that are easy to crack open. What finch would you expect to find there?

2. Hood’s island has a lot of cacti, what finch would you expect to find there?

3. Imagine that there was a drought on James Island and the small seed plants died, but some large seed plants with seeds that are hard to crack open survived. Do you think that the finches with the smallest or the largest beaks would survive?

4. What would you expect the beaks of the next generation of finches to be like? Would they be larger or smaller?

5. How could we use the rice and carrot sticks to model a drought on James Island?

2:55
Before you leave, please take five minutes to answer this exit ticket question:

Exit Ticket: Do you think that natural selection could explain why there are different species of finches on different islands? Please explain what you think happened.
<table>
<thead>
<tr>
<th>DATE 9/28/05</th>
<th><strong>Lesson topic(s) and/or Essential Question(s)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Evolution by Natural Selection</td>
</tr>
<tr>
<td></td>
<td>Darwin’s finches</td>
</tr>
<tr>
<td></td>
<td>How can we model a process that happens in nature?</td>
</tr>
<tr>
<td></td>
<td>How can we gather, represent, and interpret data?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standards</th>
<th><strong>What standards will be addressed by this lesson? (The standards are taken from the Met’s Empirical Reasoning subquestions)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What idea do I want to test?</td>
</tr>
<tr>
<td></td>
<td>What is my hypothesis? How can I test it?</td>
</tr>
<tr>
<td></td>
<td>What information (data) do I need to collect?</td>
</tr>
<tr>
<td></td>
<td>How will I collect the information?</td>
</tr>
<tr>
<td></td>
<td>What are the results of my research?</td>
</tr>
<tr>
<td></td>
<td>How will I present my results?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Objectives</th>
<th><strong>What will your students know and be able to do as a result of this lesson?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Know:</td>
<td>Darwin’s observations on the H.M.S. Beagle, combined with other ideas and evidence, eventually led him to his theory of evolution by natural selection (“descent with modification”).</td>
</tr>
<tr>
<td></td>
<td>Different species adapt to specific environments over generations.</td>
</tr>
<tr>
<td>Do:</td>
<td>Determine how to collect data from 15 student researchers.</td>
</tr>
<tr>
<td></td>
<td>Determine how to represent collected data.</td>
</tr>
<tr>
<td></td>
<td>Use an experimental model with actual biological data to formulate hypotheses.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instructional materials and resources</th>
<th><strong>What materials, texts, manipulatives, visuals, etc. will you need for this lesson? What technological resources (if any) will you need?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>5 forks</td>
<td></td>
</tr>
<tr>
<td>5 spoons</td>
<td></td>
</tr>
<tr>
<td>rice (uncooked basmati)</td>
<td></td>
</tr>
<tr>
<td>carrots in long strips</td>
<td></td>
</tr>
<tr>
<td>two large pieces of paper</td>
<td></td>
</tr>
<tr>
<td>markers for student researchers</td>
<td></td>
</tr>
<tr>
<td>map of the Galapagos</td>
<td></td>
</tr>
<tr>
<td>finch heads with information on back.</td>
<td></td>
</tr>
</tbody>
</table>

**Learner Factors**

*How does this lesson accommodate different development levels of students? How does this lesson accommodate individual differences in approaches to learning, create connections between the subject matter and student experiences, and or include provisions for students with particular learning differences or needs?*

The lesson is partly physical, kinesthetic lab, partly mathematical analysis, partly graphical representation, and partly thinking in larger abstract models and hypothetical situations. I hope that the problem of needing to represent the data in a useful way will help students think about ways to present information in their final experiment and in their exhibitions.

**Environmental Factors**

*What student grouping will be used? What changes will you need to make in the classroom due to instruction, materials, safety, etc., if any?*

Students will be assigned to a team and/or assigned a specific role in the first activity. I will assign groups of three for the second activity.

**Instructional activities and tasks**

*What activities will you and your students do and how are they connected to the objectives?*

See next page

**Assessment activities**

*How will you determine what the students know and are able to do during and as a result of the lesson?*

I will be assessing the class’ ability to work together to solve a problem and then their work in small groups. I’ll ask questions to see if students understand the basic concepts, then to see if they are able to apply them to
different situations. The work they do of looking at finches and explaining how there are different species on different islands will help me to determine how well they understand natural selection.

**Reflection**

*How did the lesson plan work? What was effective? What would you change for tomorrow or the next time you use this plan?*

I revised the lesson plan to teach it this second time. I tried to set up the outside experiment introduction section as a model and explicitly asked students to think about the connections between that model and the work we did afterward with finches inside. Students had the idea of holding the forks and spoons in their mouths, which made for a completely different competition and outcome. One student refused to compete, and I didn’t force her to. I think that the prospect of getting down on hands and knees with a utensil in one’s mouth is less appealing to some students.

I also wanted to be sure to get to the exit ticket this time around.

This time, students were much more respectful, but they were talking while the “interpreter” was trying to ask questions and hold everyone’s attention.

When we came inside, I asked everyone to give me suggestions for how I might have structured the activity differently so that people would have paid more attention. Their feedback was useful:
- use candy instead of carrots
- maybe do the analysis part of the activity inside
- make it more fun/more interesting
- make it more advanced/challenging.

I explained that sometimes simple models are used to represent complicated ideas in science, and this may seem like a very simple, childish activity, but the bigger ideas are much more advanced.
Next time, I want to do a better job of making sure everyone is still engaged and involved during the carrot activity.
**Instructional tasks and activities**  
**What activities will you and your students do and how are they connected to the objectives?**

<table>
<thead>
<tr>
<th>What will you be doing?</th>
<th>What will the students be doing?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prep: scatter rice and carrot pieces on the ground outside of the school*; hang two large pieces of paper on a wall outside (bring them inside if students seem too distracted outside)</td>
<td></td>
</tr>
<tr>
<td>* in case of inclement weather, set up on lunch room floor</td>
<td>Walking outside with a pen and paper.</td>
</tr>
<tr>
<td>2:00 Everyone grab a pen and paper, we’re going outside.</td>
<td>Silently getting into groups based on the words on their backs.</td>
</tr>
<tr>
<td>2:03 <em>Explain: for the first part of our time together, we are all going to have to work together closely to do a brief experimental model. This is an activity to get us all focused and working together.</em></td>
<td></td>
</tr>
<tr>
<td>Place assignments on students’ backs and tell them to get into groups without using any words:</td>
<td></td>
</tr>
<tr>
<td><strong>Timekeeper</strong></td>
<td></td>
</tr>
<tr>
<td>You are in charge of the collection contest. If you don’t have a watch, please get one from an advisor or student. You can decide where the competitors stand before the competition begins. You tell the competitors when to begin and after thirty seconds, tell them to stop.</td>
<td></td>
</tr>
<tr>
<td><strong>Collector</strong></td>
<td></td>
</tr>
</tbody>
</table>
You must work with the other collector to gather the data from the competition. Please record the data in whatever way you choose on one of the large pieces of paper so that everyone can see it.

**Representer**
Your task is to take the “raw” data that the collectors have gathered and to translate it into whatever form you think will be the most valuable. You can use any type of chart or graph, including those we’ve worked on this year: pie chart, bar graph, line graph, percentage or fractions, etc. Please use one of the large pieces of paper so that we can all see your representation of the data.

**Interpreter**
It is your job to guide the class through an analysis of the data as the representers have chosen to represent it. What can we learn from the data? Is anything different from what you expected? You can ask more questions of your choosing.

**Team FORK competitor**
You are an esteemed member of Team FORK. Please listen carefully to the timekeeper and carefully follow his/her directions and the instructions below: when the timekeeper says you may begin, you must try to collect as much food as you can by using ONLY the fork in your right hand. When you pick up a piece of food, transfer it into your left hand and hold it there. You must stop IMMEDIATELY
when the timekeeper tells you to stop. After you are finished, please go silently to the data collectors and open your left hand, presenting them with the food you have collected.

**Team SPOON competitor**
You are an esteemed member of Team SPOON. Please listen carefully to the timekeeper and carefully follow his/her directions and the instructions below: when the timekeeper says you may begin, you must try to collect as much food as you can by using ONLY the spoon in your right hand. When you pick up a piece of food, transfer it into your left hand and hold it there. You must stop IMMEDIATELY when the timekeeper tells you to stop. After you are finished, please go silently to the data collectors and open your left hand, presenting them with the food you have collected.

2:10 Once students are in groups, tell them they can take the paper off their backs and read their job descriptions.

2:12 Ask students to read aloud with their partner or in their group.

2:15 If anyone has any questions, please ask them now.

**Give a brief introduction to the experiment:** I want the fork and spoon competitors to pretend that you do not have hands. You only have a fork.
or a spoon to pick everything up with. If you are hungry, you can’t use your hands, you have to use the fork or spoon. Your goal is to pick up as much rice and/or carrots as you can.

2:17 Timekeeper, it’s all yours.

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2:17-2:20</td>
<td>contest</td>
</tr>
<tr>
<td>2:20-2:25</td>
<td>data collection</td>
</tr>
<tr>
<td>2:25-2:35</td>
<td>representation and analysis</td>
</tr>
<tr>
<td>2:35</td>
<td>return to classroom for finches activity</td>
</tr>
<tr>
<td>2:40</td>
<td>pass out lab sheet, finch species chart, and map of the Galapagos. Assign groups of three that are different from where they are sitting.</td>
</tr>
</tbody>
</table>

**Introduce the worksheet:** as you complete this worksheet, think back to the experiment we just did. See if you can find any connections between

<table>
<thead>
<tr>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asking any clarifying questions about their job.</td>
</tr>
<tr>
<td>Timekeeper will run the contest.</td>
</tr>
<tr>
<td>Competitors will present their collected food to the data collectors.</td>
</tr>
<tr>
<td>Data collectors will record how much of each type of food was collected by the competitors.</td>
</tr>
<tr>
<td>Representers will make a chart or several charts to show what was collected. Interpreter will lead the class through a series of questions to understand what has happened.</td>
</tr>
<tr>
<td>Walking back to the classroom.</td>
</tr>
</tbody>
</table>
our experiment and the data in front of you.

Let’s read the introduction out loud together.

In the 1830s, a boat called the H.M.S. Beagle left England to travel around the world. The naturalist on the boat was a man named Charles Darwin. Among the stops that this boat made was a couple of weeks on the Galapagos Islands, off the coast of Ecuador. You have a map of the islands in front of you, as well as a chart of some of the famous inhabitants of the islands: a type of bird known as finches.

Part One: There is a lot that all these different species of finches have in common: they mostly have similar coloration, are a similar size, and have a very similar bone structure. From looking at this chart, can you figure out what is so unique about each species of finch?

1. James Island has mostly seed plants with small seeds that are easy to crack open. What finch would you expect to find there?

2. Hood’s island has a lot of cacti, what finch would you expect to find there?

3. Imagine that there was a drought on James Island and the small seed plants died, but some large seed plants with seeds that are hard to crack open

Reading the background/introduction out loud.

Answering the sheet with partners and help from Kara and Advisors.
survived. Do you think that the finches with the smallest or the largest beaks would survive?

4. What would you expect the beaks of the next generation of finches to be like? Would they be larger or smaller?

5. How could we use the rice and carrot sticks to model a drought on James Island?

2:55
Before you leave, please take five minutes to answer this exit ticket question:

Exit Ticket: Do you think that natural selection could explain why there are different species of finches on different islands? Please explain what you think happened.
Laboratory Activity 3: Analyzing Finches

Introduction
In the 1830s, a boat called the H.M.S. Beagle left England to travel around the world. The naturalist on the boat was a man named Charles Darwin. Among the stops that this boat made was a couple of weeks on the Galapagos Islands, off the coast of Ecuador.

You have a map of the Galapagos islands and a chart of some of the famous inhabitants of the islands: a type of bird known as finches.

Part One: Looking at finches
There is a lot that all these different species of finches have in common: they mostly have similar coloration, are a similar size, and have a very similar bone structure. From looking at this chart, can you figure out what makes each species of finch unique?

Part Two: Understanding the islands
1. James Island has mostly seed plants with small seeds that are easy to crack open. What finch would you expect to find there?

2. Hood’s island has a lot of cacti, what finch would you expect to find there?

Part Three: Hypothesizing
3. Imagine that there was a drought on James Island and the small seed plants died, but some large seed plants with seeds that are hard to crack open survived. Do you think that the finches with the smallest or the largest beaks would survive?

4. What would you expect the beaks of the next generation of finches to be like? Would they be larger or smaller?

5. How could we use the rice and carrot sticks to model a drought on James Island?
Topic: The Scopes Trial/Creation v. Evolution

Materials:
A Civic Biology page
Tennessee anti-evolution act
John Scopes biography
Darrow biography
Bryan biography
4 political cartoons

Part One: Setting the Stage
1. Introduce the reading: a page copied from a biology textbook. Ask students to read the passage and prepare to discuss it later.
2. After they have read enough of the page to understand what it is about, tell students you are just going to turn on the radio but they should continue reading. Press play, (play Louis Armstrong track)
3. Mention that, by the way, it is April of 1925 and you are all in Dayton, Tennessee. Pass out the ordinance that has just been passed by the Governor, and translate it from legalese into students’ own words.
4. Could anyone make the argument that this law violates an American civil liberty? (there may be multiple suggestions, including free speech)
5. Explain: In 1925, a local football coach and math and science teacher named John Scopes assigned his students to read the exact passage that you just read. The page in front of you comes directly from a textbook called “A Civic Biology” that was popular in the 1920s. Though he never gave a formal lesson on evolution, John Scopes did believe in teaching evolution, and he agreed to be the defendant in a test case against the state of Tennessee.

A group called the American Civil Liberties Union had just started in New York, and the ACLU thought that the Tennessee law violated the first amendment right of freedom of speech. They were looking for a teacher who was willing to be formally charged with the crime of teaching evolution so that they could try to prove that the law itself was unconstitutional.

Part Two: Key players and ideas
1. Read the John Scopes biography as a group and discuss for comprehension
2. Have half the advisory read the Bryan bio and half read the Darrow bio. Ask students to highlight the 3-5 most important ideas in their article.
3. Students report out about Bryan and Darrow (advisor could compile their notes onto whiteboard)
4. Advisor hands out the political cartoons and facilitates a conversation about the meaning of the cartoons as they relate to the Scopes trial.
5. End with students giving their own opinions about the creation v. evolution debate.
Day 6 lesson plan reflection:

This lesson was taught by the two advisors while I did the finch lab with the other class. I didn't get to observe any of the classes, but it seems from Beccy and Pablo that, overall, they went well. After Beccy taught the class, she said that the biography readings weren't great and if she were doing this again, she would have liked to use different readings. Unfortunately, I didn't have time to gather new readings and revamp the lesson before Pablo taught it. However, Pablo seemed to have a good experience teaching it as well.

It was my first time preparing materials for someone else to teach, and it was a bit awkward. I also didn't give Beccy the complete lesson plan and materials far enough in advance for her to prepare them and feel comfortable teaching it.

Note:
- Beccy had found the biographies and used them for a different lesson plan on social reasoning through the Scopes Trial.
- When Beccy taught the class as a 30-minute lesson, it was too rushed. Pablo taught the lesson in an hour, and he said they got through all of the readings, but it was a long time to have students just reading and sitting still.
<table>
<thead>
<tr>
<th>DATE 10/3/05</th>
<th>Lesson topic(s) and/or Essential Question(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Evolution and Natural Selection</td>
</tr>
<tr>
<td></td>
<td>How did the theory of evolution evolve?</td>
</tr>
<tr>
<td></td>
<td>What debates about evolution have occurred within the scientific community?</td>
</tr>
<tr>
<td></td>
<td>What debates about teaching evolution have occurred?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standards</th>
<th>What standards will be addressed by this lesson? (The standards are taken from the Met’s Empirical Reasoning subquestions)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>How good is my information?</td>
</tr>
<tr>
<td></td>
<td>What error do I have?</td>
</tr>
<tr>
<td></td>
<td>What conclusions can I draw from my research?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Objectives</th>
<th>What will your students know and be able to do as a result of this lesson?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Know:</td>
</tr>
<tr>
<td></td>
<td>Understand natural selection</td>
</tr>
<tr>
<td></td>
<td>Science is not always objective</td>
</tr>
<tr>
<td></td>
<td>In order to be accepted, specific scientific evidence must be tested and approved.</td>
</tr>
<tr>
<td></td>
<td>What scientific facts and theories are accepted are often the product of social climates.</td>
</tr>
<tr>
<td></td>
<td>Do:</td>
</tr>
<tr>
<td></td>
<td>Look critically at the scientific method and recognize that it is socially and culturally bound (i.e. the method is not always the same and social and cultural factors inherently determine the path of scientific research and what is accepted)</td>
</tr>
<tr>
<td></td>
<td>Create a dynamic timeline with multiple categories of dates.</td>
</tr>
</tbody>
</table>

<p>| Instructional materials and resources | What materials, texts, manipulatives, visuals, etc. will you need for this lesson? What technological resources (if any) will you need? |</p>
<table>
<thead>
<tr>
<th><strong>Learner Factors</strong></th>
<th>How does this lesson accommodate different development levels of students? How does this lesson accommodate individual differences in approaches to learning, create connections between the subject matter and student experiences, and or include provisions for students with particular learning differences or needs?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I will go through pre-reading procedures to help students approach the textbook text, then help students to pull out important points and ideas from the text. The subject matter will connect closely to the previous class and the lab activity we did then. The class is largely reading aloud and direct presentation, but I will try to accommodate different students’ needs by writing key ideas on a flip chart and using images along with my words whenever possible.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Environmental Factors</strong></th>
<th>What student grouping will be used? What changes will you need to make in the classroom due to instruction, materials, safety, etc., if any?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>We will work as a full class to go through the text, then turn and come up with a question about evolution together. After the section on the biology of evolution, we will move into the Piltdown man activity, working in groups of three or four to solve the mystery of Piltdown man.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Instructional activities and tasks</strong></th>
<th>What activities will you and your students do and how are they connected to the objectives?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>See next page</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Assessment activities</strong></th>
<th>How will you determine what the students know and are able to do during and as a result of the lesson?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflection</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td></td>
</tr>
</tbody>
</table>

How did the lesson plan work? What was effective? What would you change for tomorrow or the next time you use this plan?

This lesson plan felt like almost a total flop. In both classes, I realized early on that students really have no idea what evolution and natural selection are. I don’t think I’ve done a good job of connecting each day’s lesson to those topics and using the work we’ve done to make the theory of evolution make sense.

In Pablo’s class:
Jesus that was hard. I structured the class as “learning the skills of a traditional science class” but many of these students are at this school because they couldn’t survive in that type of educational setting. Students seemed to be simultaneously rolling their eyes at me and not doing any more than I asked them to. Okay, only one student actually rolled her eyes, but it was frustrating that a visiting adult in the room chatted and commiserated with her. I wish there hadn’t been three adults, two of whom I didn’t know and were only there incidentally, observing this class.

As far as the lesson itself, it took way too long to read the Lamarck text (though I wouldn’t have spent less time on it, I think it was needed). I realized that these kids REALLY don’t get evolution and natural selection and I’m not sure how much the activities we’ve been doing are adding to their understanding.

The students who think they know everything already don’t seem to be adding to what they know and I’m not sure I’ve confronted many of their misconceptions.

Next time: **roaches do not “develop immunity” during
their lifetime, then pass that on. They are BORN IMMUNE.

Looking back, it might have been useful to make a chart with “born with” v. “acquired” so that students could really sort this out.

Teaching it for the second time was no easier. I taught them for the last hour of the school day and they were all exhausted. This lesson, unfortunately, was not designed to get them up and interested again.

If I were to teach the lesson again, I might go through with two groups: one reading Lamarck and one looking at the Grants’ work. That way I could have split the students who have major misconceptions about evolution from those who get the basics and are ready to move on to more science content and examples.

Next time, make sure to repeat the EXACT SAME question at the start of the lesson and at the end of the lesson if trying to confront a misconception.

Some good things that happened: I tried to teach students to mark up a text a bit, and in one class I modeled a textbook inspection pre-reading…but then we didn’t get to the textbook excerpt I’d wanted to use.

NOTE:
The original lesson plan contained five parts: review old labs, the Grants, Lamarck, Australopithecus and Piltdown Man. All I actually got done in either class was the labs review and Lamarck reading. This lesson plan draft was revised to show what we actually did.

Revised 6/2004
### Instructional tasks and activities

<table>
<thead>
<tr>
<th>Time</th>
<th>What will you be doing?</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:30-9:35</td>
<td>Introduce essential questions for the day and explain what we will be doing for the next few weeks. I am going to hand back labs #1 and #3 and we’re going to go over them together to explain the process of natural selection.</td>
</tr>
<tr>
<td>9:35-9:37</td>
<td>Hand back work</td>
</tr>
<tr>
<td>9:37-9:45</td>
<td>I’m going to run through the last few labs we did in order to explain natural selection. Please take notes and please raise your hand if you have any questions as I’m walking through this. Wrap up natural selection from the past few weeks: In the cockroach mystery… In the model outside… In the finches lab… Does anyone have any questions?</td>
</tr>
<tr>
<td>10:00</td>
<td>We’re going to go back in history a little bit. We’re going to read a little bit about a scientist before Darwin who had a different theory of evolution, a man named Lamarck.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>What will the students be doing?</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:35-9:37</td>
<td>Receiving old labs and looking at my brief comments.</td>
</tr>
<tr>
<td>9:37-9:45</td>
<td>Taking notes.</td>
</tr>
<tr>
<td>10:00</td>
<td>Asking questions about natural selection.</td>
</tr>
<tr>
<td>10:05-10:05</td>
<td>10:05-10:10</td>
</tr>
<tr>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>Pass out reading on Lamarck to dispel Lamarckian misconceptions.</td>
<td>Field questions, make sure everyone understands natural selection in Darwin’s terms.</td>
</tr>
<tr>
<td>1809: Lamarck’s theory of evolution</td>
<td></td>
</tr>
<tr>
<td>Have class read out loud, underlining important parts, stopping to summarize, and defining any new words.</td>
<td></td>
</tr>
<tr>
<td>Getting reading.</td>
<td>Reading out loud.</td>
</tr>
<tr>
<td></td>
<td>Asking questions and taking notes.</td>
</tr>
</tbody>
</table>
Lamarck’s Theory of Evolution

In 1809, the year that Darwin was born, Lamarck published his theory of how organisms changed over time.

Like many biologists of his time, Lamarck thought that *acquired characteristics* could be inherited. For example, if during its lifetime an animal somehow altered a body structure, leading to longer legs of fluffier feathers, it would pass that change on to its offspring. By this reasoning, if you spent much of your life lifting weights to build muscles, your children would inherit big muscles, too.

Lamarck’s theory of evolution is incorrect in several ways. Lamarck, like Darwin, did not know how traits are inherited. He did not know that an organism’s behavior has no effect on [the characteristics that their offspring will inherit. His theory of evolution was replaced with our modern theory of evolution, based on Darwin’s work and our understanding of genetics.]

However, Lamarck was one of the first to develop a scientific theory of evolution and realize that organisms are adapted to their environments. In this way, he paved the way for the work of later biologists.

(adapted from Miller/Levine’s *Biology*, 2002)

---

1 things you were not born with, but develop (acquire) during your lifetime, like strong fingers from playing the piano for many years.
<table>
<thead>
<tr>
<th>DATE 10/12/05</th>
<th>Lesson topic(s) and/or Essential Question(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Controversy about teaching evolution</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standards</th>
<th>What standards will be addressed by this lesson? (The standards are taken from the Met’s Empirical Reasoning subquestions)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What has other research shown? How good is my information?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Objectives</th>
<th>What will your students know and be able to do as a result of this lesson?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Know: What are some of the different views and arguments for and against teaching evolution in schools?</td>
</tr>
<tr>
<td></td>
<td>Do: read and summarize a text in a group. Share their summaries of the reading with students who haven’t read the text.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instructional materials and resources</th>
<th>What materials, texts, manipulatives, visuals, etc. will you need for this lesson? What technological resources (if any) will you need?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Five readings</td>
</tr>
<tr>
<td></td>
<td>List of student groups</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Learner Factors</th>
<th>How does this lesson accommodate different development levels of students? How does this lesson accommodate individual differences in approaches to learning, create connections between the subject matter and student experiences, and or include provisions for students with particular learning differences or needs?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I have tried to place students in groups based on what I think they will be interested in and the style of text they</td>
</tr>
</tbody>
</table>
### Environmental Factors

*What student grouping will be used? What changes will you need to make in the classroom due to instruction, materials, safety, etc., if any?*

I have intentionally mixed 9th and 11th graders and students of varying abilities and focusing skills in each group.

I am using the large cafeteria space for the lesson, so groups will be able to sit separately at round tables.

### Instructional activities and tasks

*What activities will you and your students do and how are they connected to the objectives?*

See next page

### Assessment activities

*How will you determine what the students know and are able to do during and as a result of the lesson?*

I will collect students’ jigsaw sheets and have them write an exit ticket at the end of the class.

### Reflection

*How did the lesson plan work? What was effective? What would you change for tomorrow or the next time you use this plan?*

The lesson went well: students were focused on reading and understanding the text for the most part and I enjoyed listening to their conversations. The Flying Spaghetti Monster text really requires a student or teacher to come in and realize that the guy is joking so you can figure out what the perspective under the presented perspective really is.

Revised 6/2004

<table>
<thead>
<tr>
<th>Environmental Factors</th>
<th>will be most able to engage with.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Environmental Factors</strong></td>
<td><em>What student grouping will be used? What changes will you need to make in the classroom due to instruction, materials, safety, etc., if any?</em></td>
</tr>
<tr>
<td></td>
<td>I have intentionally mixed 9th and 11th graders and students of varying abilities and focusing skills in each group.</td>
</tr>
<tr>
<td></td>
<td>I am using the large cafeteria space for the lesson, so groups will be able to sit separately at round tables.</td>
</tr>
<tr>
<td><strong>Instructional activities and tasks</strong></td>
<td><em>What activities will you and your students do and how are they connected to the objectives?</em></td>
</tr>
<tr>
<td></td>
<td>See next page</td>
</tr>
<tr>
<td><strong>Assessment activities</strong></td>
<td><em>How will you determine what the students know and are able to do during and as a result of the lesson?</em></td>
</tr>
<tr>
<td></td>
<td>I will collect students’ jigsaw sheets and have them write an exit ticket at the end of the class.</td>
</tr>
<tr>
<td><strong>Reflection</strong></td>
<td><em>How did the lesson plan work? What was effective? What would you change for tomorrow or the next time you use this plan?</em></td>
</tr>
<tr>
<td></td>
<td>The lesson went well: students were focused on reading and understanding the text for the most part and I enjoyed listening to their conversations. The Flying Spaghetti Monster text really requires a student or teacher to come in and realize that the guy is joking so you can figure out what the perspective under the presented perspective really is.</td>
</tr>
<tr>
<td>Instructional tasks and activities</td>
<td>What activities will you and your students do and how are they connected to the objectives?</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>What will you be doing?</strong></td>
<td><strong>What will the students be doing?</strong></td>
</tr>
<tr>
<td>2:00 introduce activity</td>
<td>Sitting at tables, waiting to break into groups.</td>
</tr>
<tr>
<td>Students will be broken into five reading groups and each group will have a different text.</td>
<td>Sitting in groups and receiving texts.</td>
</tr>
<tr>
<td>2:05-2:25 (20 min. to read text)</td>
<td>Reading and making sense of the text with their group...answering the questions on the handout to describe their text. Asking questions of each other, me or other adults as needed.</td>
</tr>
<tr>
<td>2:25-2:30 Get in new groups, jigsaw style (5 min.)</td>
<td>Changing groups.</td>
</tr>
<tr>
<td>2:30-2:45 Share in the group (15 min.)</td>
<td>Going around one at a time and explaining what happened in their text.</td>
</tr>
<tr>
<td>2:45-2:50 How do you think evolution should be</td>
<td>Answering the exit ticket question on a notecard.</td>
</tr>
<tr>
<td></td>
<td>Handing in exit tickets.</td>
</tr>
</tbody>
</table>
taught in schools? (5 min) *write your name on it

2:50-3:00 Hand out final portfolio assignment! (10 min)
<table>
<thead>
<tr>
<th>Text Title</th>
<th>Who? What? Where?</th>
<th>What view or views are expressed?</th>
<th>According to the text, how should evolution be taught in schools?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Teaching of Creationism Is Endorsed in New Survey

LAURIE GOODSTEIN

In a finding that is likely to intensify the debate over what to teach students about the origins of life, a poll released yesterday found that nearly two-thirds of Americans say that creationism should be taught alongside evolution in public schools.

The poll found that 42 percent of respondents held strict creationist views, agreeing that "living things have existed in their present form since the beginning of time."

In contrast, 48 percent said they believed that humans had evolved over time. But of those, 18 percent said that evolution was "guided by a supreme being," and 26 percent said that evolution occurred through natural selection. In all, 64 percent said they were open to the idea of teaching creationism in addition to evolution, while 38 percent favored replacing evolution with creationism.

The poll was conducted July 7-17 by the Pew Forum on Religion and Public Life and the Pew Research Center for the People and the Press. The questions about evolution were asked of 2,000 people. The margin of error was 2.5 percentage points.

…Eugenie C. Scott, the director of the National Center for Science Education and a prominent defender of evolution, said the findings were not surprising because "Americans react very positively to the fairness or equal time kind of argument."

"In fact, it's the strongest thing that creationists have got going for them because their science is dismal," Ms. Scott said. "But they do have American culture on their side."

The poll showed 41 percent of respondents wanted parents to have the primary say over how evolution is taught, compared with 28 percent who said teachers and scientists should decide and 21 percent who said school boards should. Asked whether they believed creationism should be taught instead of evolution, 38 percent were in favor, and 49 percent were opposed.

More of those who believe in creationism said they were "very certain" of their views (63 percent), compared with those who believe in evolution (32 percent).
2. "Intelligent Design" Not Accepted by Most Scientists by Eugenie C. Scott and Glenn Branch

This spring, a subcommittee of the Ohio Board of Education charged with supervising the preparation of the state's science education standards was petitioned by a citizens' group to include "intelligent design" (ID) along with evolution. As ID becomes better known, other state and local school boards might face similar requests.

What is ID, and does it have a legitimate place in the high school science curriculum?

ID parallels but is not identical to creation science, the view that there is scientific evidence to support the Genesis account of the creation of the earth and of life.

ID and creation science share the belief that the mainstream scientific discipline of evolution is largely incorrect. Both involve an intervening deity, but ID is more vague about what happened and when.

Indeed, ID proponents are tactically silent on an alternative to common descent. Teachers exhorted to teach ID, then, are left with little to teach other than "evolution didn't happen."

…Courts repeatedly have held that the public school classroom must be religiously neutral and that schools must not advocate religious views. In 1987 the Supreme Court ruled that teaching creationism in the public schools is unconstitutional.

ID proponents may argue that a neutral-sounding "intelligence" is responsible for design, but it is clear from the "cultural renewal" aspect of ID that a deity -- in particular, God as He is conceived of by certain conservative Christians -- is envisioned as the agent of design. While schools can take no position on this view as religion, it cannot be regarded as science.

Thus, school board members and administrators would be ill-advised to include ID in the public school science curriculum. If the scholarly aspect of ID becomes established -- if ID truly becomes incorporated into the scientific mainstream -- then, and only then, should school boards consider whether to add it to the curriculum.

Until that day, proposals to introduce ID into curricula should be met with polite but firm explanations that there is as yet no scientific evidence in favor of ID, that ID supporters are wrong to allege that evolution is intrinsically antireligious, and that the sectarian orientation of ID renders it unsuitable for constitutional reasons.

And school board members should be aware that introducing ID into the curriculum is likely to lead to strong opposition -- up to and including lawsuits -- from those, including parents, teachers, scientists, and clergy, who do not want science education to be compromised.

3. OPEN LETTER TO KANSAS SCHOOL BOARD:

CC:

- DOVER SCHOOL BOARD (PENNSYLVANIA)
- OHIO STATE SCHOOL BOARD
- RIO RANCHO SCHOOL BOARD (NEW MEXICO)
- GRANTSBURG SCHOOL BOARD (WISCONSIN)
- COBB COUNTY SCHOOL BOARD (GEORGIA)
- SHELBY COUNTY SCHOOL BOARD (TENNESSEE)
- CHARLES COUNTY SCHOOL BOARD (MARYLAND)
- NAPERVILLE SCHOOL BOARD (ILLINOIS)
- DARBY SCHOOL BOARD (MONTANA)
- BLUFFTON-HARRISON SCHOOL BOARD (INDIANA)

I am writing you with much concern after having read of your hearing to decide whether the alternative theory of Intelligent Design should be taught along with the theory of Evolution. I think we can all agree that it is important for students to hear multiple viewpoints so they can choose for themselves the theory that makes the most sense to them. I am concerned, however, that students will only hear one theory of Intelligent Design.

Let us remember that there are multiple theories of Intelligent Design. I and many others around the world are of the strong belief that the universe was created by a Flying Spaghetti Monster. It was He who created all that we see and all that we feel. We feel strongly that the overwhelming scientific evidence pointing towards evolutionary processes is nothing but a coincidence, put in place by Him.

It is for this reason that I’m writing you today, to formally request that this alternative theory be taught in your schools, along with the other two theories. In fact, I will go so far as to say, if you do not agree to do this, we will be forced to proceed with legal action. I’m sure you see where we are coming from. If the Intelligent Design theory is not based on faith, but instead another scientific theory, as is claimed, then you must also allow our theory to be taught, as it is also based on science, not on faith.

Some find that hard to believe, so it may be helpful to tell you a little more about our beliefs. We have evidence that a Flying Spaghetti Monster created the universe. None of us, of course, were around to see it, but we have written accounts of it. We have several lengthy volumes explaining all details of His power. Also, you may be surprised to hear that there are over 10 million of us, and growing. We tend to be very secretive, as many people claim our beliefs are not substantiated by observable evidence. What these people don’t understand is that He built the world to make us think the earth is older than it really is. For example, a scientist may perform a carbon-dating process on an artifact. He finds that approximately 75% of the Carbon-14 has decayed by electron emission to Nitrogen-14, and infers that this artifact is approximately 10,000 years old, as the half-life of Carbon-14 appears to be 5,730 years. But what our scientist does not realize is that
every time he makes a measurement, the Flying Spaghetti Monster is there changing the results with His Noodly Appendage. We have numerous texts that describe in detail how this can be possible and the reasons why He does this. He is of course invisible and can pass through normal matter with ease.

I’m sure you now realize how important it is that your students are taught this alternate theory. It is absolutely imperative that they realize that observable evidence is at the discretion of a Flying Spaghetti Monster. Furthermore, it is disrespectful to teach our beliefs without wearing His chosen outfit, which of course is full pirate regalia. I cannot stress the importance of this enough, and unfortunately cannot describe in detail why this must be done as I fear this letter is already becoming too long. The concise explanation is that He becomes angry if we don’t.

You may be interested to know that global warming, earthquakes, hurricanes, and other natural disasters are a direct effect of the shrinking numbers of Pirates since the 1800s. For your interest, I have included a graph of the approximate number of pirates versus the average global temperature over the last 200 years. As you can see, there is a statistically significant inverse relationship between pirates and global temperature.

In conclusion, thank you for taking the time to hear our views and beliefs. I hope I was able to convey the importance of teaching this theory to your students. We will of course be able to train the teachers in this alternate theory. I am eagerly awaiting your response, and hope dearly that no legal action will need to be taken. I think we can all look forward to the time when these three theories are given equal time in our science classrooms across the country, and eventually the world; One third time for Intelligent Design, one third time for Flying Spaghetti Monsterism, and one third time for logical conjecture.
based on overwhelming observable evidence.

Sincerely Yours,

Bobby Henderson, concerned citizen.

P.S. I have included an artistic drawing of Him creating a mountain, trees, and a midget. Remember, we are all His creatures.
4. Kansas Board Advances a Draft Critical of Evolution

By THE ASSOCIATED PRESS

TOPEKA, Kan., Aug. 9 (AP) - The State Board of Education has approved the latest draft of science standards that include greater criticism of evolution.

The board approved the draft on Tuesday by a vote to 6 to 4. It then voted to send it to be reviewed by outside academics. The board is expected to give its final approval in October.

The draft says the board is not advocating the teaching of "intelligent design," which contends that some features of the natural world are best explained by an intelligent creator, not evolution. But the language favored by the board does come from advocates of intelligent design.

In a debate on Tuesday, board members opposed to the draft said religion had no place in the science classroom.

"When mainstream science accepts this, we can put them in science classes," said Janet Waugh, who voted against the latest draft of the standards.

Proponents of the draft said they wanted a more balanced view of evolution and cited testimony from a hearing in May featuring advocates of intelligent design.

Kathy Martin, the newest board member and a former science teacher, said that opponents of the draft were overreacting and that Kansas was not going to lose any jobs or technological advancements because evolution was given a critical eye.

"I hope you guys can realize it's not going to be the end of the world," Ms. Martin said. "I hope you will try to be more open-minded."

The standards are used to develop state tests for 4th, 7th and 10th graders, with local schools having the final say on what is taught in their classrooms. Students will be tested on the new standards in the 2007-8 school year.

In 1999 the Kansas board drew international attention when it deleted most references to evolution from its science standards. Elections the next year resulted in a less conservative board, which led to the current, evolution-friendly standards. Conservatives recaptured the board's majority in the 2004 elections.
WHAT SOME STUDENTS ARE ASKING THEIR BIOLOGY TEACHERS

Critics of evolution are supplying students with prepared questions on such topics as:

- The origins of life. Why do textbooks claim that the 1953 Miller-Urey experiment shows how life's building blocks may have formed on Earth - when conditions on the early Earth were probably nothing like those used in the experiment, and the origin of life remains a mystery?
- Darwin's tree of life. Why don't textbooks discuss the "Cambrian explosion," in which all major animal groups appear together in the fossil record fully formed instead of branching from a common ancestor - thus contradicting the evolutionary tree of life?
- Vertebrate embryos. Why do textbooks use drawings of similarities in vertebrate embryos as evidence for common ancestry - even though biologists have known for over a century that vertebrate embryos are not most similar in their early stages, and the drawings are faked?
- The archaeopteryx. Why do textbooks portray this fossil as the missing link between dinosaurs and modern birds - even though modern birds are probably not descended from it, and its supposed ancestors do not appear until millions of years after it?
- Peppered moths. Why do textbooks use pictures of peppered moths camouflaged on tree trunks as evidence for natural selection - when biologists have known since the 1980s that the moths don't normally rest on tree trunks, and all the pictures have been staged?
- Darwin's finches. Why do textbooks claim that beak changes in Galapagos finches during a severe drought can explain the origin of species by natural selection - even though the changes were reversed after the drought ended, and no net evolution occurred?
- Mutant fruit flies. Why do textbooks use fruit flies with an extra pair of wings as evidence that DNA mutations can supply raw materials for evolution - even though the extra wings have no muscles and these disabled mutants cannot survive outside the laboratory?
- Human origins. Why are artists' drawings of apelike humans used to justify materialistic claims that we are just animals and our existence is a mere accident - when fossil experts cannot even agree on who our supposed ancestors were or what they looked like?
- Evolution as a fact. Why are students told that Darwin's theory of evolution is a scientific fact - even though many of its claims are based on misrepresentations of the facts?

Source: Discovery Institute

Discovery institute motto and image from www.discovery.org
Ten questions list compiled in MacDonald, 2005. from article reprint at www.cbs.com
The theory of intelligent design (ID) holds that certain features of the universe and of living things are best explained by an intelligent cause rather than an undirected process such as natural selection. ID is thus a scientific disagreement with the core claim of evolutionary theory that the apparent design of living systems is an illusion.

In a broader sense, Intelligent Design is simply the science of design detection -- how to recognize patterns arranged by an intelligent cause for a purpose. Design detection is used in a number of scientific fields, including anthropology, forensic sciences that seek to explain the cause of events such as a death or fire, cryptanalysis and the search for extraterrestrial intelligence (SETI). An inference that certain biological information may be the product of an intelligent cause can be tested or evaluated in the same manner as scientists daily test for design in other sciences.

ID is controversial because of the implications of its evidence, rather than the significant weight of its evidence. ID proponents believe science should be conducted objectively, without regard to the implications of its findings. This is particularly necessary in origins science because of its historical (and thus very subjective) nature, and because it is a science that unavoidably impacts religion. Positive evidence of design in living systems consists of the semantic, meaningful or functional nature of biological information, the lack of any known law that can explain the sequence of symbols that carry the "messages," and statistical and experimental evidence that tends to rule out chance as a plausible explanation. Other evidence challenges the adequacy of natural or material causes to explain both the origin and diversity of life.

Intelligent Design is an intellectual movement that includes a scientific research program for investigating intelligent causes and that challenges naturalistic explanations of origins which currently drive science education and research.

http://www.intelligentdesignnetwork.org/
<table>
<thead>
<tr>
<th>DATE 10/21/05</th>
<th>Lesson topic(s) and/or Essential Question(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Who decides what you learn?</td>
</tr>
<tr>
<td></td>
<td>How should we teach evolution at the Met?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standards</th>
<th>What standards will be addressed by this lesson? (The standards are taken from the Met’s Empirical Reasoning subquestions)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What conclusions can I draw from my research?</td>
</tr>
<tr>
<td></td>
<td>How will I present my results?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Objectives</th>
<th>What will your students know and be able to do as a result of this lesson?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Know: How curriculum is determined at the Met.</td>
</tr>
<tr>
<td></td>
<td>Do: Suggest curriculum guidelines or activities for other Met students and educators.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instructional materials and resources</th>
<th>What materials, texts, manipulatives, visuals, etc. will you need for this lesson? What technological resources (if any) will you need?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Copies of all activities and readings from the unit</td>
</tr>
<tr>
<td></td>
<td>List of websites on evolution, creationism, and ID</td>
</tr>
<tr>
<td></td>
<td>Textbooks and evolution books/resources</td>
</tr>
<tr>
<td></td>
<td>Checklist of things we did to learn about evolution</td>
</tr>
<tr>
<td></td>
<td>Paper for students to write position statements on GROUP LIST WRITTEN UP BEFOREHAND!!!!!!!!!</td>
</tr>
</tbody>
</table>

| Learner Factors | How does this lesson accommodate different development levels of students? How does this lesson accommodate individual differences in approaches to learning, create connections between the subject matter and student experiences, and or include provisions for students with particular learning differences or needs? |
Students will be in small groups working with students of different abilities and opinions. I hope that the students who are stronger at writing will volunteer to be the scribe within their group, while the students who are weaker will use their strengths to select teaching materials, browse the internet, and argue their opinion.

<table>
<thead>
<tr>
<th>Environmental Factors</th>
<th>What student grouping will be used? What changes will you need to make in the classroom due to instruction, materials, safety, etc., if any?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Students will be in the large group of 30 for Ben Bruder’s visit, then they will work in groups of three. We will use the common/cafeteria space and I will encourage students to use classrooms, benches, and other quiet areas to complete their group work.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instructional activities and tasks</th>
<th>What activities will you and your students do and how are they connected to the objectives?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>See next page</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assessment activities</th>
<th>How will you determine what the students know and are able to do during and as a result of the lesson?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I will be collecting a position statement on “how evolution should be taught at the Met” and the list and/or packet of resources from students.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reflection</th>
<th>How did the lesson plan work? What was effective? What would you change for tomorrow or the next time you use this plan?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Having Ben come in was great. I wish that I had engaged them in a real conversation about their own educations and how the Met is different beforehand— it’s a great starting point for connecting beliefs about teaching to how science should be taught. The process of having students come up with suggestions went alright. I think I should have given more guidance if I wanted students to come up with something that would</td>
</tr>
</tbody>
</table>
actually be useful. Also, we should have decided what
the audience would be and then spent more time on these
‘how evolution should be taught at the met’ letters. But,
many students did seem involved and were interested in
looking through all the books I brought in. A couple
didn’t think evolution should be taught at all. One came
up with some useful information on an alternative unit on
natural disasters, and another completely took advantage
of me/the assignment and went into a room to write
emails.

If I were to do this again, I might make the final project
more of a focus, this could be the wrap-up piece, rather
than introducing the new portfolio assignment as the
synthesis project.
<table>
<thead>
<tr>
<th><strong>Instructional tasks and activities</strong></th>
<th><strong>What activities will you and your students do and how are they connected to the objectives?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What will you be doing?</strong></td>
<td><strong>What will the students be doing?</strong></td>
</tr>
<tr>
<td>9:30-10:00 Special guest Ben Bruder, who is in charge of school curriculum for all Met students. He will discuss how content is determined at the Met school and how this is different from more traditional public schools.</td>
<td>Listening and answering questions with Ben.</td>
</tr>
<tr>
<td>9:55 Thank you and final questions for Ben</td>
<td></td>
</tr>
<tr>
<td>10:00 Explain what we will do today:</td>
<td></td>
</tr>
<tr>
<td>1. write a position statement:</td>
<td></td>
</tr>
<tr>
<td>2. check off the things we did that you think other advisories might enjoy/find useful.</td>
<td></td>
</tr>
<tr>
<td>3. If you want to, collect additional resources -can go online, use list of websites as a guide -look in textbooks and other reference books</td>
<td></td>
</tr>
<tr>
<td>10:05 Begin group work: hand list of groups and list of steps, tell them:</td>
<td></td>
</tr>
<tr>
<td>ready, set, GO!</td>
<td></td>
</tr>
<tr>
<td>10:12 “If you aren’t done with your position statement yet, wrap up the final sentence and move on to choosing and gathering resources.”</td>
<td>Working in groups I’ve broken up to come up with a position statement on if and how evolution should be taught. Going through pile of books and references, flipping through our old assignments and activities, and maybe going online.</td>
</tr>
</tbody>
</table>
10:23 “Finish what you are doing and come back together to wrap up our work”

If there is time:
10:25 Can one (or two) group/s summarize your position and tell us about one resource you decided to use?

10:28 Thank you all so much for allowing me the pleasure of working with you this quarter. I am looking forward to reading all of your ER portfolios and seeing some of your exhibitions next week. I will still be in the Unity building (upstairs in Andrew’s room) until December and would be more than happy to help you with any ER work you are doing or want to do.

Good luck with your work today!

The End.

| Finishing up the project. |
| Sharing their position. |
| Crying, clearly. |
How Should Evolution Be Taught at The Met?

Your goal this morning is to put together materials that students and advisors can use to teach Met students about evolution. As you have all experienced and as Ben Bruder discussed this morning, the Met curriculum is designed one student at a time and students and advisors get to select what they want to do during advisory time. For that reason, you are creating a packet of materials that students and advisors could use if they want to learn about evolution and to teach it to other students.

I have put you in groups of 2-3 based on the opinion you expressed last week on how evolution should be taught. You must work closely with your team to complete the assignment.

There are two steps to your work:

1. Write a position statement explaining how your group thinks evolution should be taught at the Met.

You can take a few minutes to discuss your position, but try to quickly agree on a shared position and have one group member write it on the cover letter (see following page).

2. List and collect materials that students and advisors can use to teach evolution through Empirical Reasoning and/or Social Reasoning.

Begin by checking off the activities and resources we've used in ER class that you think other advisories would find useful. If you want to look at copies of the materials we used, you can go to the back table to browse through them.

If you finish checking off the activities we used, you are free to find additional materials in textbooks, books on biology, books of activities, and the internet.

If you have extra time, you can print and photocopy some of the materials and attach them to your cover letter.

Please sign and print all of your names and email addresses at the bottom of the cover letter (below the word “sincerely,”).
To Whom It May Concern:

During the first quarter, our advisory has been taking a weekly class teaching Empirical Reasoning and Social Reasoning through the study of evolution. Our final assignment is to write a position statement and gather materials that other students and advisors can use to learn and teach about evolution.

Our Position on How Evolution Should Be Taught at The Met:

Materials that you might find useful for teaching and learning about evolution:
- Candle observation lab
- The Cockroach mystery activity
- The "analyzing finches" lab
- A trip to the RISD Nature Lab
- A reading on Lamarck’s theory of evolution
- Guest presentation on the Galapagos Islands
- Articles expressing different opinions on how evolution should be taught

Other materials we’ve collected:

Sincerely,
First Quarter ER Portfolio

This quarter we have completed a series of Empirical Reasoning labs and activities. Your ER portfolio is an opportunity to reflect on the work you have done and to bring it together as evidence of your learning for yourself and others.

1. Pull out your ER folder and make sure that all the work you have done is inside. If something you did is missing, speak to Kara and we’ll try to find it. Check each piece of work off on this list as you find it.

Your folder should include:
   o Day one questionnaire
   o Candle observation lab
   o The Cockroach mystery activity
   o The “analyzing finches” lab (with my comments and your response to my comments)
   o Your RISD Nature Lab drawings with a written description of the thing(s) you observed
   o Our reading on Lamarck’s theory of evolution with notes written on the page and the notes you took in class that day
   o Notes from Professor Wakeford’s visit
   o Texts about teaching evolution worksheet
   o Your written opinion on how evolution should be taught
   o Your group’s final position statement and materials for advisors to teach about evolution (you will do this in class next week)

2. Choose one scientific skill or method that you feel you have worked on a lot or gotten better at this quarter. Skills and methods you might choose include observing, recording data, analyzing data, asking questions, making conclusions, and hypothesizing. If you want to focus on a different skill, speak to Kara.

3. Write an introduction to the portfolio in which you:
   a. Give an overview of what we did in ER class this quarter (1-2 sentences)
   b. List some of the important skills and methods that scientists use (2-3 sentences)
   c. Describe the one skill or method that you worked on/improved in ER this quarter (1 sentence)
   d. Explain why this method is an important part of empirical reasoning (2 sentences)

4. Choose three pieces of work that are all evidence of that scientific skill or method.

5. For each piece of work you choose, write one paragraph in which you:
   a. Describe the piece of work and the activity that it was part of (2-3 sentences)
b. Explain how the piece of work is evidence of the skill or method you’ve chosen (2-3 sentences)
c. Explain why you are proud of this piece of work and/or what you would do to improve it (1-2 sentences)

6. Write a conclusion to the portfolio in which you:
   a. Summarize what you’ve learned in ER this quarter (2-3 sentences)
   b. Describe three ways that you plan to continue doing ER for the rest of this school year (2-3 sentences)

7. Write a table of contents (see model)

8. Make a cover page (see model), but feel free to decorate and be creative with your cover page!

9. Find a way to put all the pieces together in a final, presentable form that you can hand in to Kara, show at your exhibition, and include in your growing body of work you are proud of.
ER Portfolio Model

Please use this model as a guide when you design your own title page and table of contents.

Title Page:

“Analyzing Data Rocks My World”
Empirical Reasoning Portfolio

Name

’s Advisory
First Quarter, 2005

Table of Contents

Introduction .................................................................................................................. 1
Reflection on Candle Lab .......................................................................................... 2
Candle Lab ............................................................................................................... 3
Reflection on Lamarck notes .................................................................................. 5
Lamarck notes ......................................................................................................... 6
Reflection on “how evolution should be taught” ...................................................... 7
“how evolution should be taught” ........................................................................... 8
Conclusion .............................................................................................................. 9

Appendix: other work

• Day one questionnaire
• The Cockroach mystery activity
• Class notes
• The “analyzing finches” lab (with my comments and your response to my comments)
• RISD Nature Lab drawings with a written description of the butterfly I observed
• Reading about Lamarck
• Anything you did when Professor Wakeford came to visit
• My summary of the articles on the controversy about teaching evolution
• My group’s final position statement and materials for advisors to teach about evolution
Chapter Three: Reflection on Teaching about Evolution

The experience of teaching the eight-week unit on evolution to 9th and 11th graders was one of the most rewarding parts of my student-teaching experience. I had the luxury of teaching each lesson twice, allowing me to reflect and revise each lesson and then to teach it again. Often the changes I made were notes to myself: take more time on this, make sure to ask this question as planned, try to move them quickly through this part so that it doesn’t drag, etc. Other times, I partially or completely changed the lesson plan before teaching it to the second group. In the day-to-day reflection and editing, I focused on what was successful in the classroom, and used the experience of teaching on that day to plan any changes.

After completing the unit, I can reflect more broadly on how well I met the goals I set for the entire eight week program. To guide the self-evaluation and reflection, I have my initial goals as stated in the unit plan and the set of twelve guidelines for Science Studies Education as outlined in the introduction and elaborated in the literature review.

As described in the unit plan, I hoped that students would, at the end of the unit, understand the basic concept of evolution by natural selection, the scientific v. popular definitions of “theory” and how the word is used in creationism/intelligent design v. evolution debates, why anyone cares what is taught in schools, who decides what they are taught, and why evolution is such a ‘hot topic.’ I wanted students to be able to look critically at their own ideas about what is true and what type/s of expertise they believe,
to carefully observe data, verbalize observations, and make inferences from observations, and to accurately record the work they did in our class and complete a lab report.

The first and most content-specific goal is the one I am least confident about: at the end of eight weeks on the topic, I am not sure how well my students understand the concept of evolution by natural selection. As I led them through activities that provide useful analogies, models, and ways of thinking about evolution and the nature of science, I do not think I provided enough of a concrete, authoritative definition of evolution for my students who had no experience with the concept to grab onto. When I teach the unit again, I want to focus more on leading students through a process of creating a useful definition and understanding of evolution through each activity. In other words, I need to be more transparent and guide my students to understand exactly why we are doing each activity and exactly how it is connected to evolution.

The lesson that tried to help students understand the scientific versus popular definitions of the word “theory” was one of the least successful for several reasons. The first is that the lesson attempted to work with definitions of a word outside of any other context. Just defining the word ‘theory’ for no apparent reason and without connecting it to an activity or experience did not work for most of my students. Secondly, I had a revelation during the lesson that I was doing exactly what I hoped Science Studies Education would avoid: using the power of Science to draw lines in the sand between science and non-science. If I were to teach this lesson again, I would not begin by presenting the definitions of theory in science v. outside of science. Instead, I would first get students to be comfortable with hypotheses and making their own hypotheses, and would then discuss some scientific theories, like the theory of gravity or germ theory, as a
way to move into understanding what a theory is and how it is different from an ‘educated guess.’ I would not intentionally reify the science/outside science boundaries, but would instead focus on what the word ‘theory’ in the theory of evolution means (with all its processes, components, and unknowns), as opposed to the way that intelligent design proponents use the word ‘theory’ to undermine evolution. A good resource for the next time I teach might be Ken Miller’s response to the stickers that were placed in his textbooks in Georgia (Miller 2005).

One of the most important parts of the unit, for me, was to encourage students to think critically about how what they learn in school is determined and why there is so much controversy over who controls what students learn. Because the Met is such a different educational model, the day we spent discussing education was rightly an opportunity for them to reflect on how curriculum is determined at the Met and to compare their experience at the Met to the more traditional schools they were in previously. We did not get a chance to talk in depth about the larger systems that determine curriculum content outside the Met, but it was even more important that they be engaged in a conversation about their own learning, and that was certainly achieved with the help of Ben Bruder, our special guest in charge of curriculum at the school.

The unit successfully demonstrated to students that evolution is a very hot topic, particularly through the disagreeing articles they read on one of the final days of class. I’m not sure, however, that I did an effective job of setting the stage for them to understand why it is so hot. If I were to teach the unit again, I would want to have students look more explicitly at what is at stake in how evolution is taught in schools. It would be easy to devote an entire day to the question “so what?” toward the end of the
unit, and I would like to do a better job of encouraging students to ask the question “so what?” as we go through the entire unit.

In the end, two of the most important questions of the unit remained somewhat unanswered: “what is evolution?” and “why does anyone care how you learn about it?” Particularly in a once or twice weekly class, I need to make a greater effort to keep the bigger picture and the main essential questions in plain sight for me and for my students. If I were to clearly write and review the essential questions each day, briefly review and connect to what we have learned already, and connect each activity concretely to the big questions, I think my students would better understand the purpose of each class and be able to put it all together to answer the bigger questions.

As far as the performance goals I set, I think that the course did push students to think about what types of expertise they believe, but it did not push them enough. If we had more time, I would have liked to have them engage closely with one of the opinion texts we read, to clearly locate their own opinion in relation to that article, to carefully examine the source of the article and list reasons they would or would not trust this expert opinion, and to write their own longer opinion piece individually.

For the most part, students did a good job of recording their observations and all of the work that we did in class. If I were to teach the unit again with more time, I would have spent some time modeling good note-taking for students, because I do not think their note-taking skills are very well developed yet. I also would have liked to incorporate more labs and to have students write at least a few of the segments of a more formal lab report. Again, there just was not enough time to fit everything into this unit.
To assess how well the unit met the guidelines I have set for Science Studies Education, I will approach the guidelines thematically and reflect back on the ways in which each was met or overlooked in the eight week course.

As far as the pedagogical underpinnings of the class, the course did a reasonably good job of staying true to the set guidelines. As an educator, I always look at education as a constructivist process that, like science, creates knowledge, and creates the world (SSE 9), and this perspective guides my planning and teaching. To some extent, no matter what methods I used in the classroom, I would still see the process as one of constructing knowledge, even if that were only through direct teacher presentations and ‘cookbook’ pre-determined result lab activities; activities that are not considered to be constructivist techniques. Constructivism, as discussed in the literature review, takes specific research and theories about how good learning happens and tries to create intentional learning situations where students are actively involved in the process of making new knowledge. I both approached the unit with a constructivist perspective and tried to incorporate constructivist activities into classroom planning, including assessing students’ prior knowledge, structuring the lessons around their knowledge and questions, and revising labs so that students are creating new knowledge rather than spitting out pre-determined results.

As suggested in Clough and Clark’s article on cookbook labs and constructivism, teachers can revise pre-existing ‘cookbook’ activities so that students are using prior knowledge and experiences and actively constructing knowledge (Clough and Clark 1994). One particular activity that I revised to meet constructivist goals was the finch modeling lab. In the activity, students first acted out a model of competing to eat carrots.
and rice with different types of utensils, then had to come up with their own model to explain the divergent evolution of finches on the Galapagos Islands. I did not give them the finch activity with a clean-cut explanation of how it represented the finch problem. Instead, I pushed them to make the connections themselves and to try to use the same materials we had used together to create their own models for explaining a new situation.

The unit also involved students in the process of thinking about and deciding what and how they learn (SSE 8). The majority of the unit was planned out by me in advance, and students did not have a lot of say in what we learned in the day-to-day. However, the unit itself explicitly led students through the process of thinking about how content is determined in their school and forced them to articulate their own positions on how evolution should be taught and to find curriculum materials for other teachers and students to use.

I think that the final project did encourage critical reflection on the world (SSE 10). Students were forced to think about and express their personal beliefs, to carefully examine how they are being educated at their new school, and to explain what they think should be done in the world of science teaching. Additionally, by having them read a series of articles from different positions forced them to make sense of someone else’s opinion, locate their own opinion in relation to someone else’s and to realize how many different opinions are already out there on this topic. Asking students to look at a variety of opinions and then to answer the question “what do you think should be done?” forces them to look critically at their world and to cast their own judgments on it.

The evolution unit attempted to incorporate learning about the history and philosophy of science, the nature of science, and science and technology studies. The
history of science (SSE 1) was explicitly taught in the lessons on Darwin and the Galapagos and the Scopes trial. In our trip to the Rhode Island School of Design’s Nature Lab, I used the history of scientific illustration and the advent of technologies to capture images as a backdrop for student work in careful observation and drawing.

As far as the philosophy and nature of science, students were encouraged to study science as a discipline (SSE 2) through much of the unit. The first two weeks focused specifically on the nature of science, with students completing a class survey “consensogram” activity answering questions about their own beliefs on the nature of science. The final portfolio assignment, which asked students to choose a method or skill that scientists use and to collect evidence of their own use and development of that method, both encouraged students to look at science as a discipline and presented science as a way of knowing with specific rules, methods, and characteristics (SSE 3). If I were to teach the unit again, I would like to further emphasize that science is one of many possible ways of knowing and to look more carefully at why science is such a powerful way of knowing.

The unit looked at and talked about scientists as people in several ways. In the introductory activity, students stepped in and out of a circle to show which activities on a list of things scientists do are things that they themselves do. Students were encouraged, from the beginning, to think about the work that they do as the work of scientists, and to think about what scientists do in their professional lives. Later in the unit, we discussed specific scientists, including Darwin and Lamarck and the basic times and contexts of their lives. I had originally hoped to bring a scientist into the classroom or to bring my students to a lab to get to see “science in action,” but we did not get a chance to do so. If
I were to teach the unit again, I would love to have my students do a laboratory study project as part of our study of science and scientists as people.

My original unit plan incorporated learning about the intersections of evolution, race, and racism into the lesson (SSE 6), but these biological-social themes were the easiest to pull out of the curriculum when I started to run out of time. There may never be enough time to cover all that I would like to cover on a specific unit. And unfortunately, on the day I had planned to explore the connections between science and the struggle for racial equality, I realized that none of my students could define evolution. I had to take a step back to increase their understanding, and then ended up cutting the theme of race and racism entirely from the curriculum. I did not get to teach it at all in that class (though I had hoped it would be the focus), but I did design a short, three-session unit for my 12th grade class that only looks at evolution and race. Though I was not able to incorporate the material into the larger evolution unit, I now have the experience of teaching it as a series of shorter workshops and I feel confident that I could include the themes in an evolution curriculum the next time I teach it.

I attempted to make the existing boundaries between science and society clear and to question those boundaries (SSE 5) through the topic of teaching evolution in schools. In the final weeks of class, students grappled with the questions of what should be taught in school, how science and society are placed at odds in the evolution debate, and where some draw the lines between appropriate and inappropriate content for the science classroom. As in the case of defining the word ‘theory’ in and outside of science, I found it difficult not to mimic most supporters of teaching evolution by reifying the science v. society boundaries. Because the evolution side of the evolution v. intelligent design
debate tends to appeal to science’s power and objective knowledge and to reject
intelligent design as non-science, it is difficult to locate myself on the evolution side of
the fence without falling into what I see as epistemological traps.

One way to better address this problem of positioning might have been to
explicitly discuss and question science’s unique position of power and privilege as a
narrative (SSE 4) with my students. Without explicitly presenting science as parallel or
comparable to other narratives, it isn’t possible to discuss science’s unique position of
power very well. When I teach the unit again, I would like to include a lesson early on
about the history of the scientific method, then a discussion of how that method creates
“reliable,” “acceptable” information. Later in the unit, I would love to really engage my
students in comparing science, intelligent design, and religion as different ways of
knowing and to lead them to an understanding of how and why each one is valued as it is.

It is difficult to determine how to value students’ partial perspectives (SSE 12) in
the evolution classroom. So much of the evolution/creationism debate focuses on the
idea that there are only two perspectives and that they are at odds, and there is a great
deal of pressure on science teachers who want to teach evolution to teach it as one
scientific truth, with no space in the classroom for what students might think. In terms of
science content, I tried to understand, value, and work through each student’s
misconceptions, though I wish I had been able to do even more assessment and teaching
targeted to misunderstandings. The final assignment tried to give validity to all students’
perspectives on the evolution/creationism debate, and I hope that by writing them in exit
tickets, talking to other students about them, and putting them into a proposal for other
teachers and students to use, they did feel that their individual knowledges and perspectives were valued and valuable.

Finally, I want to consider whether the unit offered tangible hope and actions for a better future and involved students in the process of taking the theory and ideas they are learning and putting them into practice in their own lives and in the world (SSE 11). I hope that the unit seemed hopeful to my students. I think that the final assignment of putting together materials for other students and advisors to use was a great idea, and involved them in thinking about what they learned and how they can put that into action in a next step. Though it was an authentic assessment, we did not have an authentic audience selected for the piece and with only 30 minutes to create the whole thing, there was not time to get it polished and decide where and how to deliver it. If I were to teach the unit again, I would certainly spend more time with that project and make it a truly authentic, deliverable end product.
Chapter Four: Introduction to Sex and Gender Curriculum

“...while discussions involving gays and lesbians are gaining a limited foothold in schools, issues of those who identify as transgendered or queer seem to draw increased uneasiness...this discomfort translates into curricular silences.”
(Lutz. And Mac. 155)

In the months I spent researching and preparing this curriculum, I have encountered vast and loud silence. I have found very little research on transgender youth in schools, few materials for teaching the biology of gender to high school students, and I have not yet found any discussion of teaching about transgender or intersex in the high school classroom. In the world of high school curricula, discomfort about gender and sexual difference engenders silence, and that silence is deafening.

For the purposes of this paper and the curriculum, I will try to give biologically and common usage-accurate definitions of transgender, transsexual, and intersex. Transgender refers to people who transgress gender boundaries, who live all or some part of their life as a gender other than the one they were assigned at birth, be it male, female, or something else entirely. Transsexual refers to people who may have had some form of body modification surgery and/or hormone replacement therapy to alter their body, most often as part of identifying as a gender other than the one they were assigned at birth. Intersex refers to people who do not fit in to the biological sex binary of male and female, and for whom some aspect of their sex, be it chromosomal, hormonal, external or internal genitalia and organs, assigned sex at birth, developmental sex during adolescence, etc. does not align with some other aspect of their sex.

While humans have transgressed gender boundaries and changed their physical bodies to fit their own self-concept since time immemorial, the concept of transgender is
just now gaining a foothold as part of queer/lesbian/gay/bisexual experience. Transgender legal rights, medical access, and protection from harassment are starting to appear as an essential part of queer/LGB struggles and agendas. As Reis says in *Teaching Transgender History, Identity, and Politics*, “Transgender is out of the closet, and it should be in the classroom as well” (166). Over the last few years, LGB centers have been tacking on Ts to their acronyms, but the mere inclusion of the letter “T” belies the lack of information, research, and resources on transgender.

Intersex is in some ways even more complex. While there is general consensus that including transgender in LGBT politics and priorities is a good thing, there is a great deal of debate about what intersex means and where it should lie as a social movement. Some activists call for intersex to be included in the queer acronyms, creating something like LGBTQI. Others do not want to be associated with LGBT people or politics and are against such inclusion. Some people who are intersex do not want to be defined as ‘intersex people’ and instead choose the language ‘people with intersex condition/s’ (ISNA), emphasizing that intersex is a medical condition and a problem of shaming, not an identity.

I am entering into this project with a number of underlying assumptions. I personally identify as queer and have had the experience of being in a relationship for several years with a person going through a female-to-male gender transition. My own queer identity and my identity as the partner of someone transgender inform my beliefs that teaching about transgender identities and tolerance of gender differences are essential and noble goals. I have my own stories and experiences of being a queer young person going through a public high school and private university, and the realities of isolation,
stigmatization, and homophobia are realities I have felt personally. On top of this, I am assuming that ‘promoting diversity’ and ‘teaching tolerance’ are worthwhile goals in the classroom, and that it is useful to encourage high school students to critique Western thought and critique the institution of science in science class. I am struggling to negotiate content and outside goals in this curriculum, and do not want to greatly sacrifice breadth and depth of scientific content for the sake of promoting a personal ‘agenda.’ I know that this will be a continuing struggle and tension that I encounter as a queer educator with radical politics, and I look forward to negotiating that challenge as I go.

Program goals

My commitment to devising the program stems from my own critique of the way that sex and gender are usually presented to students. The way that embryonic development, human reproduction, and genetics are usually taught in high school biology classes reinforces a strict sex and gender binary: you must be a masculine male or a feminine female, and you must be attracted to people of the opposite sex. Most curricula make no mention of alternative possibilities for biological sex, performance of gender, or sexual orientation. A science curriculum that leaves out these facts reinforces assumed gender roles, promotes fear and violence against transgender, transsexual, and intersex people, and hurts queer, gender-variant and questioning youth, and all marginalized young people.

This program is designed to accomplish a number of content, thematic, conceptual, and attitude change goals. The content goals are to teach about embryo
development, human reproduction, and genetics through the theme of the biology of sex and gender. The ultimate attitude and personal change goals are to create a safe and caring community for all students, to promote tolerance, and to encourage students to think critically about the world and culture they live in.

Addressing a Need

The program I propose is simultaneously focused on a sub-group of students (transgender, gender-different, queer, intersex, and questioning youth) and intended for all students. Some of the most urgent justifications for teaching the curriculum are specifically targeted to queer and more specifically to transgender and gender-different students, who deserve and are rarely given a safe, caring environment in which to learn. At the same time, the overarching goals and themes are essential for all students and justify teaching the curriculum to everyone.

Transgender and LGBQ students

A note on terminology: it is presently in vogue to use the ‘catchall’ term LGBT, or lesbian, gay, bisexual, transgender. I prefer to include a Q for queer, and/or questioning folks and for the purpose of this paper, will defy convention and flip the order to TLGBQ, emphasizing and making visible the transgender youth whom I am primarily focusing on. When citing the work of other authors, such as GLSEN’s report, I use the terminology used by the author.

We live in a society which violently punishes deviation. Heterosexuality and careful adherence to prescribed gender roles are promoted as the norm from which any
divergence is perverse. Within high schools, the culture of gender and sexuality policing can be particularly vicious. For many students, whether or not they identify as TLGBQ, deviation from the norm can bring on bullying, harassment, and violence.

TLGBQ students constantly encounter stigmatization, discrimination, numerous social and health problems, harassment, and violence. According to the Gay, Lesbian, and Straight Education Network’s (GLSEN) 2001 National School Climate Survey, the only national survey documenting LGBT youth experiences in high schools, 84.3% of LGBT students reported hearing homophobic remarks like “faggot” or “dyke” frequently or often. 23.6% reported hearing homophobic remarks from faculty or staff at least some of the time, and 81.8% said teachers and staff never or rarely intervened when a homophobic remark was made. 89.5% of transgender students reported feeling unsafe based on their gender expression and 73.7% reported being sexually harassed (GLSEN 2001). Gay and Lesbian youth are estimated to be up to six times more likely to attempt suicide, make up as much as 42% of runaways, and have dramatically higher cocaine use than their peers (Mufioz-Plaza, 53). Whether or not they are victims of severe harassment, violence, and tragedy, TLGBQ students experience severe cognitive, social, and emotional isolation in high school (Martin and Hetrick, 1988). It is the responsibility of teachers and staff to create a supportive environment and a school culture in which all students can feel safe and learn.

In “Lesbian, Gay, Bisexual and Transgender Students: perceived social support in the HS environment,” Mufioz-Plaza describes the social supports that TLGBQ students need but rarely get in school, which include emotional support, appraisal and feedback, instrumental support (time and resources), and informational support. In addition,
schools need to welcome and actively celebrate diversity, including diversity of sexuality and gender expression. Schools need to train staff on LGBT issues and sensitivity, design sex-ed curricula that discuss LGBT issues beyond HIV/AIDS, and teach LGBT topics in the classroom. According to the GLSEN survey, 80.6% of LGBT students reported that there were no positive portrayals of LGBT people, history or events in any of their classes. For reasons of safety and support, there is a desperate need to expand curricula to include TLGBQ issues and voices.

_A Curriculum for All Students_

While one of the goals of the program is to make a safe, supportive environment for TLGBQ students, the overarching themes and broader aims are intended for all students.

Homophobia and transphobia, and more generally speaking, gender-deviance-phobia, often appeal to arguments of what is normal/abnormal and natural/unnatural. As Reis says in _Teaching Transgender History, Identity, and Politics_, “People embrace deeply rooted ideas about what is “normal” and “natural” and they tend to regard with suspicion those practices that seem to conflict with these standards” (Reis, 167). The interdisciplinary unit, therefore, hopes to separate “normal” from “natural,” to look critically at how we use both of them, to look openly at ideas and practices that conflict with our own personal or cultural standards, and to critically examine those standards. This will challenge transphobic and homophobic ideas that students bring into the classroom and will encourage them to think critically about how the ideas of normal and natural are used to give authority to specific arguments.
The assumption that there are two genders, male and female, and that there can be nothing in between underlies intolerance of gender deviance. Anything or anyone that does not fit neatly into one of the two boxes is seen as unnatural, abnormal, and dangerous. This is a product of Western thought’s obsession with duality and dichotomy. Western thinking, and particularly Western science, is very much consumed with black and white, wrong and right, and this way of thinking is not universal across cultures. As Peng and Nisbett show in *Culture, Dialectics, and Reasoning About Contradiction*, Chinese culture has much more tolerance for fluidity and ambiguity, and is much more accepting of gender deviance from and between what is designated ‘male’ and ‘female.’ Challenging the Anglo-European way of seeing the world and showing that it is culturally specific is a wonderful way to encourage all students to think critically about the world and culture they live in and to see the possibility of alternatives.

I believe that questions of sex and gender, of how we are taught that we must be male/female, and of how we choose to be male/female, or something else entirely, are important issues for everyone. As Reis explains, “...although transsexuality directly involves a small proportion of the population, issues of gender affect us all, even if we believe to fit neatly into the generally accepted male or female boxes” (Reis 168). For young men and women who are going through puberty and coming to see their bodies as sexed and sexual in new ways, the curriculum provides an opportunity to look critically back at the people and stories in their lives that are dictating what it means to be male or female. The program also deals with stereotypes and fights those stereotypes with the realities of who we all are as individuals. Celebrating deviation from strict societal
norms, fighting stereotype, and being true to who you really are and want to be are essential lessons for all students.

Science is a uniquely powerful knowledge and narrative, and the teaching of science has the power to reify existing truths and social structures or to challenge them. Presenting the facts of the naturally occurring diversity of gender breaks down the argument that deviating from gender norms is not natural and focuses attention instead on how gender is created, how male v. female boxes are made, and who gets to decide what is normal. The science classroom can and should be a place where students are asking real questions, challenging the answers they are fed, and learning how to sort through and gather their own information to make meaning of the world that they live in.

**Teaching in a specific cultural context**

I am aware entering into the project that I will be teaching students who are racially and culturally different from me. I will be a young white female teacher in a classroom that is at least 70% students of color, and I want to remain sensitive to the challenges of teaching “other people’s children” as I design and implement the curriculum. As Lisa Delpit explains in her book Other People’s Children, teaching students whose home cultures are different from my own without being aware of those differences can be inherently harmful to students. The curriculum is designed to encourage students to share their outside experiences and what they have learned at home and elsewhere, and to explicitly talk about the ways that different cultures manage and experience gender differently. In my final reflection on teaching the curriculum, I will
describe specific instances in the classroom where race and/or cultural differences were discussed, and reflect critically on my treatment of the issues in the classroom.

**Predicting Successes and Challenges**

It is not easy to predict how students will respond to the actual implementation of the program. I know that I am entering into a classroom where a lot of students use homophobic slurs like fag, dyke, and the seemingly more innocuous “that’s so gay.” I anticipate that at least some students will make a mental connection between the ideas of intersex, transgender and homosexuality, and I want to be sure that they clearly understand how the concepts are different, and some of the complex ways in which they can be connected. I also need to be prepared to answer questions and respond to student discomfort, disagreement, and even anger about the material I am presenting. Students may think that learning about intersex people is offensive or disgusting, and even if student responses are mostly curious, engaged, and positive, I can not predict how parents will respond.

If I am asked to justify teaching these topics in the classroom, I will appeal to many of the arguments I have presented here, that the overall goal is to teach content, support all students, and teach tolerance and critical thinking, and that the subject of sex and gender is a useful way to do all of this. I know that I am teaching the program in a school that supports my goals and the program itself and that will defend me if there are any complaints from students or parents. When I decided to teach the curriculum this fall, I first made sure that I had the explicit support from my cooperating teacher, other
teachers, and the school administration before I began. Each time I teach it, I plan to do the same.

It is also difficult to anticipate the precise impact of the program. I have far-reaching goals for the program and know that I can not expect all of them to be fully achieved and that it will be hard to measure such things as an increase in tolerance or critical thinking. As my advisor Anne Fausto-Sterling said when we were discussing the program content, if the students emerge knowing what normal and natural mean and that the two things are different, that alone is a real accomplishment. I hope that I am able to measure student responses to the program when I actually do implement it and I plan to keep modifying the program as I receive real student feedback.

**Conclusion**

This program is simultaneously far-reaching and limited in scope. It is a work in progress and a project that I plan to revise and rework over the coming year. This Fall I have had the opportunity to teach the curriculum in two different classrooms, and I hope to be able to revise and teach it again in another school later this year. I am also continuing the research process, working with other educators and organizations to search out more resources that will help me to improve and expand the project.
Chapter Five: Biology of Sex and Gender Unit

Unit Plan: Biology of Sex and Gender

(Science segment of an interdisciplinary unit on "normal" and "natural")
Prepared by: Kara Wentworth

Overview: This unit is designed for a group of fifteen 9th and 11th grade female students at an alternative public high school in Providence, RI. The unit explores gender stereotypes, the separate definitions of sex and gender, and the biology of intersex. The same group of students will attend each 30-minute workshop on Friday mornings over the course of five weeks. After the completion of the unit, the students will continue meeting weekly with other educators leading different gender and sex-related topics.

Essential Questions:
- How do we learn what we know about gender?
- What don’t we learn about the biology and anatomy of sex?

Guiding Questions:

Gender:
- What does being female/male mean to you?
- What do other people (family, friends, tv, music and music videos, books…) say that being female/male means?
- How is your unique way of being female/male similar/different from what other people tell you?

Sex:
- How does an embryo develop? And how does it “choose a sex”?
- What happens when a baby is born that doesn't fit in the box of "male" or "female"?
- Who decides what gender a baby is assigned at birth?
- What does intersex mean and when is that word used? What does hermaphrodite mean and when is that word used?

Performance Goals/skills:
Students will be able:
- To look critically at their own ideas about what men and women should be like and compare to those of their peers.
To differentiate between “sex” and “gender”.
To understand what it means to be intersex and that it is relatively common for people to biologically not fit in one of two sex boxes.

Attitude outcomes/objectives:
Students will:
• Be more introspective about their own gender presentation in relation to gender norms
• Be more respectful of people who transgress gender boundaries, and accept transgender, transsexual, and intersex people as “natural” and valuable individuals.
• Be more critical of the messages they get from the media, from family, from peers, and other sources.

Assessments:
• Personal collage
• Writing reflection: based on Jamaica Kincaid’s Girl
• Exit tickets

Activities/minilessons:
• Male box/Female box activity
• Jamaica Kincaid’s Girl and learning what it means to be female
• Sex v. gender v. sexual orientation
• Embryo development
• Intersex anatomy and social issues
Part 1: Exploring Gender Stereotypes

Session One: Male box/Female box

Objective: Open a dialogue about gender stereotypes and how we learn them.

Materials:
- A large collection of magazine cut-outs (50+), including words, objects, and images.
- Two boxes (e.g. milk crates or shoeboxes), one labeled “Male” and one labeled “Female.”
- White paper, one piece for each student
- Pens and markers
- A manila envelope or folder marked “confidential”

Introduction:
Welcome to gender group! You will be meeting every Friday for the entire school year, and I will be here for the first month or so. Introduce the idea of gender stereotypes and explain the sorting activity.

Activity: Sorting Male/Female Boxes
1. Place two boxes in the middle of the table
2. Pull one magazine cut out and show it to everyone at the table. Ask whether it belongs in the male box or the female box; place it in the box students assign it to.
3. Continue step 3 until about half of the cut-outs are sorted
4. Pass out the remaining cut-outs to students in groups of two or three and ask them to sort into male and female.
5. Have students present to the group each cut-out and where they’ve decided to place it, then place it in the assigned box if there is no opposition from the class.

Discussion:
- Great Job! You all agreed on pretty much every image or word and knew which box to place it in. How did you all learn how to do that so well? Did you learn it in school? Did a teacher devote one day to learning about gender? Did you all buy the same book about gender and learn from that? (Students may mention people they learned from, family members, etc... and/or media: magazines, movies, TV, etc... or some other source entirely)
- Ask students to elaborate on their claims, to share specific details, to discuss specific television shows, movies, news outlets, books, or magazines. Probe for specific memories, things people said, ways they have felt or were treated. Be prepared to discuss how individual experiences are different and cultural differences in gender.

Exit Ticket:
Write about a specific person or television show (or whatever the discussion has focused on) that taught you about gender. What did you learn and how? Be specific!
*have students fold these in half and place in the confidential folder to take out next time.
Session Two: *Girl*

**Objective:** Encourage students to think more deeply about where they received messages about how to be female and to explore their own ways of being who they are.

**Materials:**
- Copies of Jamaica Kincaid’s *Girl* for each participant
- Male box and Female box with sorted cut-outs inside from last week
- Confidential folder with students’ exit tickets from last week
- Glue sticks
- Pens and markers

**Introduction:** Check in to see how people are doing. Try a whip around the room, where each student has to give one word to explain how they feel right now. Recap what we did last week/ask a student to recap.

**Reading:**
1. Pass out Jamaica Kincaid’s *Girl*.
2. Have students volunteer to read out loud; try to have as many students speak as possible.
3. Who is speaking in the story? How can you tell? What is the story about? What literary techniques does Jamaica Kincaid use?

**Assignment:**
Perhaps thinking back to the reflection you wrote at the end of class last week, write your own *Girl* in your journal. It will be collected and read by your advisor before our next meeting.

**Collage:**
Pass back the reflections that students wrote last week and place the male and female boxes in the middle of the table.
1. Ask two students to each lift one of the boxes and to dump its contents out in the middle of the table.
2. Have all the participants mix the images and words to form one big pile.
3. For the next activity, don’t think about gender stereotypes, just think about yourselves. Make a collage that represents you, using any of the words and images in the pile.
4. Students make personal collages using glue sticks, a piece of paper (can be the back of the paper they wrote on last time) and the magazine cut-out images and words.

**Debrief (if there is time):** Have students share their collages. How did it feel to make the collage? What did you think about? Did you think about gender stereotypes? Did you remember which box we had placed each image or word in? Was anything uncomfortable about the experience? Was anything particularly positive?
Session Three: *Sex v. Gender and Sex Differentiation*

**Objective:** Understand the difference between biological sex, gender, and sexual orientation, and establish the language we will use in the rest of our sessions.

**Materials:**
- Flip chart
- Markers
- Note cards
- Handout: Sexual Differentiation in Embryos
- Handout: Male and Female reproductive anatomy

**Recap:** For the last two weeks, we have been talking about gender: how we are taught to and how we choose to act and present ourselves as female. The words sex and gender are often used interchangeably, like on forms you have to fill out: sometimes it will say sex and sometimes gender. But in our gender groups, we will distinguish between sex (i.e. biological sex) and gender.

**The Chart:**
Let’s start a chart to separate sex and gender. *Place headings sex and gender up first. Move into sexual orientation as soon as it comes up in student comments (e.g. listing “lesbian” as a category that belongs on the gender list) or else when it seems appropriate. Have students fill in the categories in each section. Emphasize that the work intersex is now used and hermaphrodite is considered offensive. Ask students to identify where a ‘metrosexual’ would fall in each category.*

<table>
<thead>
<tr>
<th>Sex</th>
<th>Gender</th>
<th>Sexual Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>Masculine</td>
<td>Gay Lesbian Homosexual</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Straight/Heterosexual</td>
</tr>
<tr>
<td>Intersex</td>
<td>Androgynous</td>
<td>Bisexual</td>
</tr>
<tr>
<td>Female</td>
<td>Feminine ...</td>
<td>Queer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asexual ...</td>
</tr>
</tbody>
</table>

**Embryo Development:**
Has anyone ever had a baby or has someone really close to you had a baby? When can you find out if it’s a boy or a girl? Does a pregnancy test tell you? Embryos don’t actually choose their sex until 7 weeks into a pregnancy. Up until that point, we all look more or less the same.

1. Look at male and female anatomy diagrams to get a reference point; make sure everyone knows where the clitoris is.
2. Look at embryo development chart and guide students through interpreting the chart.
3. Explain that male, female, & intersex are possible outcomes of sex differentiation.

**Exit ticket:**
1. What did you find most interesting today?
2. What is one question you have?
Student Responses to Session Three: *Sex v. Gender and Sex Differentiation*

**What I found Interesting:**
- Similarities between the development of sex organs.
- I really didn’t learn anything, I just know that I have to take care of my body. I really don’t like talking about this because I know all of this. (Greta)
- What I found interesting was everything.
- I want the class to be more *interesting*.
- The sex, gender, and sexual orientation.
- I learned how the male part and female part diverges.
- It’s interesting that metrosexual is now a scientific term!
- That people are so different.
- How the embryos form the sex of a baby was interesting.
- I never knew there was another gender called androgynous.

**Questions:**
- Is the male organ really the female organ inside out?
- What I want to learn more about is like womanly diseases etc.
- More about sex (like having sex)
- What I want to learn anything
- I want to learn more about mehapidits.
Session Four: Sexual Differentiation and Intersex

Objective: Students will understand intersex as one possible outcome of sexual differentiation.

Materials:
- Sex, gender, sexual orientation poster from last week
- Computer, projector, and screen/wall
- Handouts from last week: Sexual Differentiation in Embryos & Male and Female reproductive anatomy
- Handouts: “phall-o-metrics,” true v. pseudo hermaphrodites, common types of intersexuality

Entrance activity: Ask how everyone is doing today. Lead the class through a visualization exercise where they are on a tropical beach with a virgin pina colada in hand…ask them to return to the classroom when they are ready. (note: this is not related to the lesson content, but was a necessary intro activity on a gloomy, rainy day)

Recap: Hang sex, gender, sexual orientation poster from last week and have someone who was here recap the three sections of the chart for those who missed the last session. Have someone else recap what “metrosexual” means to show the possible connections between elements from each column.

Genital Development: Last time we looked at drawings of the path of genital development in a fetus. This is what happens for the majority of fetuses, and when they pop out the doctors say: “It’s a Boy!” or “It’s a Girl!” and they are usually right. But often, a baby is born who isn’t exactly male and isn’t exactly female. When this happens, we say the baby is intersex. Today we are going to explore genital development and intersex through a great web-based tool from a Canadian children’s hospital.

1. Walk through the “Anatomy,” then “Development” sections of the sickkids.ot.ca Child Physiology website. Take questions from students along the way and make connections back to the handout diagrams.
2. Show a preview of the “Conditions” section of the site to prepare students for next week’s focus on intersex.

Exit Ticket: What is one specific question that you want me to answer next time?
Student Responses to Session Four: *Sex Differentiation and Intersex*

Questions:

- What happens when you are intersex?
  - Puberty
  - Birth
  - Etc…
- What happens to the kids that are intersex?
- Can intersex be passed on/is it genetic?
- What are the different sex (biology) you can be? How does it look?
- How does it look? (intersex)
- For someone who is intersex, how would there be room for the vagina and the penis to fit in the same place?
- What does hermaphrodite look like?
- I wouldn’t like to learn nothing about this, because I know all of this. I don’t like doing Gender Group. But if other people wants to talk about it it’s alright. I just don’t like when people (adults) talk about this every single year (Greta)
- Can you have both parts and still have children?
- Can the parents decide if they want their baby to keep both sex (penis & vagina) or does the doctor automatically remove the extra one?
- Can the parents choose if they want a girl or a boy?
Questions

? How is there room for a penis and a vagina?

? What does "intersex" look like?

? What happens at birth?

Questions

? How is there room for a penis and a vagina?

? What does "intersex" look like?

? What happens at birth?

? What happens during puberty?
Questions

? How is there room for a penis and a vagina?
? What does “intersex” look like?
? What happens at birth?
? What happens during puberty?
? Can parents decide if their intersex child gets surgery?

Biological Sex

More than just a penis and a vagina!

- Chromosomal Sex
- Internal Organs
- External Organs (genitals)
- Secondary Sex Characteristics

Chromosomal sex

- XX
- XY
- XXY
- XO

Internal Organs

- Ovaries
- Uterus
- Testes
- Seminal Vesicles

External Organs (genitals)

- Clitoris
- Vaginal opening
- Labia (lips)
- Penis
- Scrotum
Secondary Sex Characteristics

Female
- Breasts
- Pubic and body hair
- Wider hips

Male
- Deeper voice
- Pubic, body, and facial hair

A Penis and a Vagina?

“True Hermaphrodite”
- Ovary and testes or ovo-testes

“Pseudo Hermaphrodite”
- Ovaries with male external genitalia
  or
- Testes with female external genitalia

A Penis and a Vagina?

“True Hermaphroditism” is a relatively rare type of intersexuality, and “true hermaphrodites” rarely have fully formed male AND female external genitalia.

Types of intersex

Most types of intersex involve a combination of “male” and “female” sex characteristics: genes, hormones, internal and external anatomy, and secondary sex characteristics.

Different types of Intersexuality

- CAH
- Hypospadias

What does “intersex” look like?
CAH and Hypospadias

What does this type of intersexuality look like?

What happens at birth?

What happens during puberty?

Phall-o-metrics

- Baby is born
- Doctor notices external genitalia
- Often parents are told that this is a rare occurrence and there aren’t resources or other parents to get more information from
- Doctors make a decision with the help of parents or without fully explaining the options to parents

Phall-o-metrics cont…

- If surgery is performed, there are usually additional surgeries as they child grows up
- Some patients are unable to experience sexual pleasure after the surgeries
- Often (as in case of CAH) the surgery is to make the genitals look more “like they are supposed to” but might not be medically necessary
- Sometimes patients are not told what happened and find out by investigating their own medical records

What do you think should happen?
Reflection on Sessions One and Two:

It was hard to get a conversation going. I wonder how I can build that needed comfort really quickly when we just have a series of thirty-minute workshops...how can I do that better and faster? Have them talk to each other more? Be flexible and prepared to do a turn-and-talk at any time if it gets slow/like pulling teeth? I’m not sure if people enjoyed it at all or how much they got out of it. I think that they should have cut things out of magazines to put in the boxes so it would be them thinking of what things they have learned are male/female, not my own guess about what they’ve been told (which, even if I’m clipping from Latina magazine is the guess of a white feminist who grew up watching free to be you and me).

I did not get to read their “girl” writing pieces but will ask Beccy about them at some point.

Reflection on Session Three:

Students seemed really engaged as we were making the chart and adding things to it, but it got a little slow as I tried to explain what a metrosexual is: sex, gender, sexual orientation separately, I may have spent too much time on that rather than moving on to say, okay so then what would a “tomboy” be?

Questions to ask next time/comments to follow up on:

1. If you are a tomboy does that mean you are or will be a lesbian?
2. Sex and Gender can be/are independent, so a super feminine man could be all the way at the “feminine” end of the spectrum, though he is biologically at the male end of the spectrum.

Notes for the future:

*Be careful not to make a vertical spectrum, with male at the top!!!!
*you may have to do the whole chart in one fell swoop, someone will mention homosexual as a gender or something else that will require you to have all three columns and fill them all in thoroughly.
*Only give one question for an exit ticket! AND write it up so they can refer to it visually!

Reflection on Session Four:

They seemed to be having a great time with this stuff. I wish now that I had started with the sex/gender stuff rather than the mushier gender sessions at the beginning…or maybe one mushy section to lead in to the rest. Then again, maybe they are able to warm to me and the material because of the sessions we’ve had already…it is impossible to know how they would have responded if I introduced this on the first day.

They all seemed sympathetic to the intersex kids and parents. One student blurted out: I would want to know! When I explained that doctors have operated on babies, perhaps removing an enlarged clitoris, without ever telling the patient what really happened.

Their questions for next time provide a perfect opportunity for me to prepare a really great DTP for next week. Exciting!
Chapter Six: Sex and Gender Reflection

To evaluate the sex and gender unit, I first want to take a step back and reflect on several incidents and themes that I grappled with in the classroom. I will later evaluate the success of the curriculum relative to the goals I set and to relevant guidelines for Science Studies Education.

I am particularly struck by two elements of the experience of teaching my sex and gender curriculum: one is my confrontation with my own boundaries for talking and teaching about sex, and the other is the intersections of race and class that enter into the classroom conversations.

It took several weeks for the 9th and 11th grade girls to get warmed up and comfortable enough with me, with each other, and with the material of our workshops. By the final sessions, they were confidently asking explicit, pointed, challenging questions out loud. On our last day, as we looked at drawings of the external and internal reproductive anatomy of someone with Congenital Adrenal Hyperplasia (CAH), students asked some wonderful questions. A person with CAH is genetically female (XX) and has female internal reproductive organs, but external genitalia that are to some extent masculinized. The result is that people with CAH have a uterus and ovaries with anywhere from an enlarged clitoris to a fully formed penis and scrotum on the outside.

One student asked if people with CAH can have sex. Another asked if they could get pregnant. I answered both questions comfortably: of course you could have sex, sex is more than just penis-vagina sexual intercourse, so any person is capable of ‘having sex’ with anyone else. And people with CAH may have a vaginal opening and/or enlarged phallus, so they can absolutely have intercourse and more generally, have sex.
however they want to. With regard to fertility, people with CAH are potentially capable of female reproduction, so if impregnation is possible, then pregnancy is also possible. If the vaginal opening was not large enough for natural childbirth, a person could have a caesarean section.

The next question took me a little off guard: one student wanted to know if a person with CAH would ejaculate, and if they did, would they shoot out eggs? In retrospect, I am blown away by the student’s ability to process, construct, and articulate this question: she was doing everything I want my students to be able to do. She was drawing analogies between what she knows about male and female reproductive anatomies, she was combining that information to make sense of a new biological possibility she was unfamiliar with, she was to some degree identifying with and caring about what it would be like to have CAH, and she was willing and able to ask a graphic and risky question in front of her peers.

I asked her to hold off on that question while I answered another student’s question and got my bearings. When I returned to answer her ejaculation question, I had her repeat the question again and then began to give an answer as best I could. I first explained the basics of male ejaculation: ejaculate fluid, sperm, swelling of tissue, and excitement. As a person with CAH would not have testes, sperm, or ejaculate fluid, they would not ejaculate in the way that a person with male internal reproductive organs would. And since eggs are in limited supply and only one or a few descend each month, they would not be shot out rapid-fire by any mechanism.
However, I added, all women can ejaculate. Female ejaculation, I explained, is different from male ejaculation and is connected to stimulating the G-spot, which we talked about two weeks ago.

There were no more questions on the topic and we moved on in exploring CAH and reproductive anatomy. It was not until after the class was over that it really hit me: I had just taught my high school students about female ejaculation. I told the story to a few people, beginning with: “I think I really crossed a line in class today…” But what line had I crossed in the context of an open dialogue on sex and sexuality? In retrospect, I realize I had crossed several of my own boundaries.

What is it that makes female ejaculation taboo but male ejaculation appropriate content for a high school classroom? Perhaps more importantly, what are the internal boundaries that I am crossing as I venture into specific territory in talking about sex with high school students?

First, there is a problem of source. My knowledge of male reproductive anatomy is almost entirely from my health and biology classes, not from firsthand sexual experience. When I describe male ejaculation, I genuinely think of diagrams of the vas deferens and testes, not of sexual experiences. Because I learned about male sexual parts and function in my high school classroom, it seems like obviously appropriate material for the classroom in which I’m teaching.

Female ejaculation, on the other hand, was never mentioned in my high school classes. I did not learn about it until I became sexually active myself, and my knowledge comes from personal experience, from reading ‘sex-positive’ books in sex toy stores, from talking to friends, and from my sexual partners. When I am talking about female
ejaculation, there is no textbook cartoon for my mind to fixate on; instead, I am thinking about sex.

Is there a rule that teachers must be asexual? How can an educator be expected to talk and teach about sex and sexuality without ever thinking about, well, sex?

The next problem is the problem of pleasure. In a science or health classroom, talking about parts and functions is acceptable; talking about pleasure as separate from the parts and functions seems dangerous. Male pleasure is privileged on this stage, because it is directly tied to basic parts and reproductive functions: to discuss male reproductive anatomy, we talk about erection, sperm, ejaculation. Male pleasure enjoys its unchallenged link to reproduction; female pleasure is afforded no such luxury.

The second aspect of teaching the sex and gender curriculum that particularly stood out to me was the ways in which class and race came up in the classroom. As a white teacher in a mostly non-white classroom, I was very much aware of the moments in which race and class differences arose and was particularly conscious of my and my students’ handling of these moments. On the first day with my 9th and 11th grade students, I was careful to bring magazine cutouts from a range of magazines, some of which are targeted to my students, such as Hispanic Business Magazine and Latina. After going through the cut-outs and separating them based on gender stereotypes, some students started to talk about television shows as one place that they’ve learned gender stereotypes from. Among other themes, they brought up the differences between “new” and “old-school” TV shows and between what they called “white shows” and what I then called “shows with people of color.”
My students came to consensus that white shows reinforce gender stereotypes more than shows with people of color. However, black old-school shows like The Cosby Show showed a family model where the mother stays at home and takes care of the house and kids while the father works. I encouraged my students to continue this conversation about racial and cultural representations of gender on television and tried to get their observations and opinions out on the table as much as possible. I was able to probe for and encourage student responses by validating the topic of racial difference as appropriate and valuable for our classroom. However, the conversation did not get to go far enough. I wish that we had had more time to talk about telenovelas, newer shows with black main characters, and the relative paucity of Hispanic-focused shows on network television.

A different but related racial issue came up in my work with the twelfth grade students. On the first day of our sex and gender unit, I introduced the sex V. gender V. sexual orientation chart as a way to define “metrosexual,” a term that was being thrown around a lot in our classroom. After we established that a metrosexual would be biologically male, have a feminine gender presentation, and be attracted to people of the opposite sex, my students wanted to figure out what the “opposite” of a metrosexual would be, or the relative female counterpart. They concluded that it would be a straight tomboy. Another student then asked: where would homothug be on the chart? Would that be a gender?

Unfortunately, as is often the case, the class time was coming to an end when this fabulous question was posed. A homothug, as I understand, is a self-identification or label used by and for gay males who are openly gay and present a more masculine, butch
'thug' aesthetic. But the very word ‘thug’ stands in for racial and class categories, not for gender. In order to explain where a homothug would fit into our sex/gender/sexual orientation, we would need to somehow incorporate the dimension of racial and class identity and presentation into the chart itself. In the moment, I decided to place homothug as a category of gender presentation and hoped that we would have time to return to it another day.

Unit goals

The performance goals I set for students in these workshops were to look critically at their own ideas about what men and women should be like and compare to those of their peers, to differentiate between “sex” and “gender,” and to understand what it means to be intersex and that it is relatively common for people to biologically not fit in one of two sex boxes. I also outlined separate attitude objectives: that students would be more introspective about their own gender presentation in relation to gender norms, be more respectful of people who transgress gender boundaries, accept transgender, transsexual, and intersex people as “natural” and valuable individuals, and be more critical of the messages they get from the media, from family, from peers, and other sources.

In the workshops with my 9th and 11th grade female students, I think that we set and met these modest goals. The first two days of the workshops focused entirely on gender and how we’ve learned what it means to be women. Students shared some of their own stories, reflected privately, critiqued media representations of gender, and created a collage using images and words that we had labeled as male/female based on
gender stereotypes. Creating the collages was a way for students to actively express themselves and to reflect on the ways in which they have accepted or resisted different gender stereotypes. Students were able, after a few days of reviewing the concepts, to separate sex from gender using the chart we created in class, and they understood intersex as a category for anyone who doesn’t fit into the male or female boxes for biological sex.

There were a number of moments and comments that convinced me my students were becoming more accepting and even empathetic toward intersex people. A few students talked about how they would feel if they were born intersex, namely that they would want to know exactly what happened and not have their doctors or parents hiding anything from them. Other students thought about what it would be like to have a child who was born intersex, and I realize now that this has to have a solid place in the curriculum as I teach the material in the future. The only downside of their imagining and empathizing was that several students left on the final day saying: I don’t ever want to have children if they could turn out like that.

In the short time remaining, I tried to encourage students to see that being born intersex doesn’t mean the end of someone’s life or that they will have to live a life of pain and shame. Because many of these young women already think of themselves as potential future mothers (and some already are mothers in my 12th grade group), I need to do a better job of leading them through role-playing as the parent of an intersex baby so that they could get the resources for themselves or a friend whose child is born intersex. Though preventing pregnancy is a nice byproduct of the lesson, I do not want students to walk away thinking that having a child who is intersex would be a terrible, impossible challenge.
When I taught the biology of sex and gender unit later in the semester to my mixed-gender 12th grade students, I entered the classroom on the final day and introduced myself as a pediatrician at the hospital, and welcomed all of my students as new parents. I explained to them that they were brought together for this first meeting of a support and information group for parents of children with CAH, and described all of the supports they would receive from the hospital and beyond as they embarked on the journey of learning more about their child’s condition and making decisions for and eventually with their child. I also introduced students to several websites with additional resources for parents of intersex children and, once their children are old enough, for the children themselves, to learn more about and connect with other people who have been through similar experiences. By presenting intersex as a reality that parents and their children can navigate and cope with, the 12th grade students left feeling, in their own words, that they would “know how to handle it if our own kid was born intersex or if we met someone who is.” By concluding with an enacted real world situation and giving my students the resources they would need if they or someone they know needs to learn more about what intersex means in the future, my 12th grade students left the unit feeling both empathetic and empowered.

Science Studies Education

In evaluating the sex and gender unit, some of the Science Studies Education goals are useful benchmarks and others did not apply. Because the unit did not focus on science, it did not incorporate the history and philosophy of science, present science as a way of knowing with specific rules, methods, and characteristics, examine and question
science’s unique position of power/privilege as a narrative, look at and talk about scientists as people, nor encourage students to study science as a discipline. The remaining Science Studies Education Guidelines have helped me to review and reflect on the success of the curriculum.

Because of my own philosophy of education, any unit I teach will see education as a constructivist process that, like science, creates knowledge, and creates the world (SSE 9). I do not think it is necessary for students to entirely understand this aspect of my philosophy, but it guides all of my planning and teaching in every class and workshop. In justifying and setting my goals for the unit, I assume that what happens in my classroom creates knowledge among the participants and creates the tone and content of the world ‘outside.’

The unit focuses on the biology of sex and gender, a topic rooted in biology and society (SSE 6). I think that the process of distinguishing between sex and gender and discussing the ways in which the two are connected and layered made alleged boundaries between science (sex) and society (gender) clear, and also questioned those boundaries (SSE 5).

The unit explicitly involved students in the process of thinking about and deciding what and how they will learn (SSE 8) by asking students to write down one question they had or one topic they wanted to explore further at the end of each lesson. Students knew that the content of the following session would be guided by their interests and questions each time. In the final session, I explicitly incorporated every single student question into my PowerPoint presentation and used them to set the structure for the slides and teaching that day. By writing their own questions and presenting them in my PowerPoint slides, I
also seemed to open the door for students to feel even more confident asking questions and guiding the direction of the lesson based on their interests.

The unit encouraged students to look critically at their own world (SSE 10) in several ways. First, the two introductory lessons on gender engaged students in a process of examining how the media and their own families have taught them about gender roles. Students produced their own writing and artwork to express what they have learned and to speak out against it by separating what they have been taught to believe and follow from what they themselves believe and enact. Later in the unit, when we learned more about intersex anatomy and medical issues, many students were angry with the treatment many intersex patients and their families have received, and spoke critically of what are often taken as normal practices.

When discussing a topic as personal as sex and gender, it was even more important to me to try to values students’ partial perspectives (SSE 12) in the classroom. I wanted to give students as many opportunities as possible to record their own thoughts and feelings so that even students who were not comfortable sharing their thoughts with the group would be able to record their feelings and experiences. On the first day of class, I had each student write a personal memory about how they were taught how to be female, to fold it in half, and to place it in a folder marked “confidential.” As we passed this confidential folder around the room, each inserting our own reflection, I enjoyed the metaphor of many partial perspectives placed next to one another to form a whole of the experiences contained within our group. The following week, we all pulled our private reflections out to read them again, and used them as inspiration (and in some cases background) for our personal collages.
The final guideline and, in my opinion, the most important one, is that the unit should offer tangible hope and actions for a better future (SSE 11). As I have described, the take-home message for some of my students seemed to be: “watch out! This could happen to you!,” scaring them away from having children with the fear that they might be intersex. With a topic like the biology of sex and gender, I think it is necessary to end the unit with some sort of action for change, or at the very least, planning possible actions for change. An end-in-action approach would accomplish the second part of the guideline, by involving students in the process of taking the theory and ideas they are learning and putting it into practice in their own lives and in the world (SSE 11).

When I teach the unit again, I want to insert action points or action planning points into the lesson plans. One possible way to plan action after discussing gender would be to think about how gender operates in our school, and if there are any places in the school where young women are getting messages they do not like or do not agree with about how to be female. Students could also pool together their understandings of gender stereotypes and how they have resisted some of them (e.g. students agreed that the word ‘power’ should actually be associated with women, though the stereotype is that it is associated with men), and create a curriculum, workshop, or event for younger female students. I also want to show students inspiring models of group action creating changes, such as the Intersex Society of North America’s (ISNA) impact on medical practices around handling of intersex births. I was able to do this briefly with my 12th grade students but want to focus on the topic more as I teach the curriculum in the future.
Conclusion

The thesis attempts to enact the theory of praxis: putting theory into practice in the world, and reflecting honestly and critically on the process. In reflecting on the two curricula, I revealed a number of challenges and points of resistance for the work I was trying to do in the classroom. There are a number of places in which new curricula encounter resistance, including but not limited to: the need to teach specific content, fear of new curricula, the traditional structure of the high school as an institution, and the students themselves, who have learned how to learn and what is expected of them in traditional classrooms.

The first point of resistance is at the level of required content. In most schools, what is to be taught is determined, to a large extent, by what can be easily tested. Therefore, content requirements in all subject areas, and especially in science, focus on discrete knowledge and facts that can be tested with a multiple-choice exam. Our nation’s current sweep of education reform, headed by the federal No Child Left Behind (NCLB) legislation, is pushing toward more specific state-wide content standards in all subjects, including science. Based on the stipulations of NCLB, as of the 2007-2008 school year, all states must have mandatory state-wide science tests at least once in 3-5th, once in 6-9th and once in 10-12th grades (Janofsky 2005). As Brooks and Brooks explain in In Search of Understanding: The Case for Constructivist Classrooms, the current test-based reform movement is antithetical to the constructivist understanding of learning and teaching: “The dynamic nature of learning makes it difficult to capture on assessment instruments that limit the boundaries of knowledge and expression” (viii). Contrary to the aims of constructivist education, current U.S. Secretary of Education Margaret
Spellings insists that “what-gets-measured-gets-done,” so the only way to improve science education is to mandate standardized testing (Janofsky).

In addition to state-wide standards, high schools also base much of their curriculum planning on what colleges expect students to have done, and the SATII subject tests and advanced placement exams have come to control curriculum in many college-preparatory high schools. In my student-teaching experience I was very much shielded from exam-driven content requirements. At The Met, there is no required content knowledge my students had to cover in biology, so I was free to teach and omit whatever themes and topics I wanted. However, I set specific expectations as to what content knowledge I would cover in each curriculum, and had to struggle with the content standards I had outlined for myself. In teaching the evolution curriculum, I found that it was possible to teach about evolution without having students really thoroughly understand the definition and concept of evolution. I learned part way through the teaching experience that no amount of activities and lab work would bring students to a clear definition of evolution; I had to more explicitly present and define evolution for students to understand the concept.

Another point of resistance I faced was the constraint of time. In order to ensure that my students understood the basics of evolution, I was forced to cut out one of the most interesting pieces of the curriculum: an exploration of the links between evolution and racism. When time is limited, it is easier to cut out a lesson that links the science content to social issues than to eliminate a lesson that clarifies the basic content and definition of evolution. Unfortunately, this same reasoning leads many teachers choose to take evolution out entirely, since it seems easier to cut out a controversial topic than
one that everyone agrees should be taught. I imagine that the problem of cutting out the controversial or ‘social’ material from a curriculum will be a major challenge for enacting Science Studies Education, and I want to find ways in the future to both make sure I am completely confident and comfortable with the more controversial and ‘social’ material in the curriculum and that it is an integral part of the curriculum.

Another level of resistance is institutional: high schools are deeply entrenched in their own systems and structures. The resistance to institutional change creates a culture of conservatism in most high schools. Since I was at The Met, a school that prides itself on ‘thinking outside the box’, I did not encounter the level of resistance for my curricula that I might have encountered in a more traditional school. Instead, I faced a different sort of institutional resistance: the schedule and structures of the Met are so fluid that it was a challenge to teach a more traditionally structured class.

Because my classes had a much more traditional structure than any of their other learning experiences at the school, I encountered some resistance from students. Many Met students are at the school because the traditional format of education did not work for them, so it was challenging for me to teach to an entire room of students who had already rejected the one-teacher, many-students model. Because my students have rejected traditional schooling to a large degree, it was a challenge to get them to buy into my class and to get into the rhythm of regular group meeting times and activities.

There were several challenges I grappled with that are specific to teaching a Science Studies Education curriculum. The first is the challenge of negotiating a position on the ‘correct’ side of public debates while staying true to the tenets of Science Studies scholarship. In the current evolution/intelligent design debates, there is a pro-
Critical insights without opportunities for students to reconstruct a world rich in the wonders of race, culture, gender, and social justice may wound a sense of possibility…without engaging in an activist pedagogy that educates students of color in the history and politics of successfully fighting conditions of injustice, well-meaning educators may risk exposing students to a sense of disempowerment.  (Pastor et al., 29-30)

I am concerned that in practice, my curricula did not engage students in what Pastor et al. call ‘an activist pedagogy.’  In the sex and gender unit, many of my students left with a better understanding of what intersex means, but with the feeling that they couldn’t possibly handle having an intersex baby themselves.  My 9th and 11th grade students left with more knowledge, but felt disempowered.  In the evolution unit, I planned a final assessment project that engaged students in proposing new school curricula, but I did not follow through to make the project an authentic product that could be delivered to the alleged recipients (other Met students and advisors).  In planning Science Studies Education curricula in the future, I want to begin by designing an assessment tool that produces authentic, tangible, hopeful action in the world.  From there I can design a curriculum that leads students through the swamps of critical questioning and analysis towards real hope and tangible action to make change in the world.

There are a number of changes I would make to the curricula and my teaching if I were to teach these units again.  I did not do a good job in either curriculum of presenting science as a way of knowing.  To do so, I would have to present it along with other ways of knowing and I hope to incorporate an analysis and comparison of multiple ways of knowing at the start of the next science class I teach.  This would also be a great way to get students to think about and question expertise and ask questions about data, information, and opinions.  I could also use this part of the unit as an opportunity to teach
students how to identify useful internet sources and how to evaluate an unknown source by looking for funding and affiliations and other key indicators.

I would also like to incorporate laboratory studies work into the curriculum. Students could take a ‘shadow day’ trip to a laboratory to observe scientists at work and report on the experience as an anthropologist observing a foreign culture. This would meet the goal of seeing scientists as people (SSE 7), and would give students a ticket into the culture and practices of doing science.

A final change I will make in my next teaching experience is to keep the bigger goals and picture in plain sight at all times. I want to be more diligent about communicating the goals and essential questions of each lesson to my students, and explaining—for myself and for them—how each lesson fits into the broader context and goals of the unit. This is a simple way to make my teaching more transparent and to involve students in the process of thinking about what and how they are learning (SSE 8).

These case studies are limited in scope, but they provide a starting point from which to discuss the promise of Science Studies Education in a broader context. Many of the challenges I faced when designing and teaching the curricula will likely be encountered by other educators who wish to pursue a similar path: balancing testable, concrete content knowledge with the goals of Science Studies Education.

These curricula and the guidelines for science education are works in progress. As I revise and teach these and other science curricula, the guidelines themselves will surely shift and change. The next step for me will be entering the teaching profession as a certified biology teacher and grappling with my own teaching and curriculum design on a daily basis. I hope that the experience of teaching in my own classroom will provide
new insights and inspirations for me to further articulate my philosophy of science education and new points of access for me to engage with the ideas and thinkers of Science Studies and education theory.

Paolo Freire speaks not of teachers and students but of student-teachers and teacher-students (67). During this first semester of teaching, I was very literally a student-teacher: a student of teaching and an enrolled undergraduate completing coursework and this thesis project. The process of researching, creating, teaching, revising, and reflecting on my teaching unit forced me to be a fully engaged teacher and student at the same time. I hope to carry this flame with me into my next teaching job, and to continue learning from inspiring writers and educators and from my students as I go.

In the spirit of Science Studies Education, I want to conclude with an inspiring vision of the purpose of education from Lisa Delpit’s book Other People’s Children.

A few years ago, I asked Oscar Kwageley, a friend, teacher, Yupik Eskimo scientist, and wise man, what the purpose of education is. His response startled me and opened my eyes even more: he said, “The purpose of education is to learn to die satiated with life.” That, I believe, is what we need to bring to our schools: experiences that are so full of the wonder of life, so full of connectedness, so embedded in the context of our communities, so brilliant in the insights that we develop and the analyses that we devise, that all of us, teachers and students alike, can learn to live lives that leave us truly satisfied. (104)

Science Studies Education proposes exactly this practice: at its best, it offers experiences that are full of the wonder of life and connectedness, embedded in our communities, and brilliant in its insights and analyses, allowing us all to learn to live lives that leave us truly satisfied.
Works Cited


McComas, William F. “Ten Myths of Science: Reexamining What We Think We Know About the Nature of Science.” School Mathematics and Science 96(1) January 1996: 10-16.


