Why this lesson, for these students, at this time? - Developing a new 1st year SWS Biology Course

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Project Rational and My Target Audience.

The first year I taught at Brookline High School (BHS), the Assistant Headmaster, Victor Melehov, gave a speech about the Saber-Tooth Curriculum (Benjamin 1939) and the lessons that it can teach us. He outline how early in Paleolithic time, the skill of wooly horse clubbing was essential to the success and failure of young cave people of the time. Clubbing horses became a staple of public Paleolithic education and remained even after the wooly horses traveled east out of clubbing distance. Harold R. W. Benjamin's 1939 satirical account of the education still rings true today. The curriculums we teach need to be relevant to the time and the population.

Currently the Biology I Honor curriculum is targeted at an AP light level. Students are asked to sift through large amounts of content and we squeeze in a lab when we can. The class is traditional in that it focuses on bookwork and lecture. The class is highly structured around objectives and packets that target the students directly at answers. This method has merits but leaves little room for digression or elaboration. It can produce factual knowledge of Biology but is lacking in higher order Biology thinking skills. To generalize the students slightly, they become the passive receivers of information and the teacher becomes the all-knowing repository of Biology facts. The students can recall but cannot critically think about Biology. I have recently joined the *School within a School* (SWS) program at BHS, and the shift in student population has prompted me to take a closer look at my current teaching methods in Biology I honor, which I am currently teaching to SWS students.

The SWS program at BHS has a three pronged mission that is currently fluid and under development. The program strives to 1) maintain high academic standards, 2) cultivate a small caring learning community and 3) maintain an environment of justice and student empowerment. The program is optional and students are accepted based on a lottery system. There are approximately 120 sophomores, juniors and seniors that comprise the SWS student community. The students that are attracted to SWS have often felt marginalized in the mainstream population and tend to value the close-knit environment of SWS. SWS students and staff all participate in a

weekly town meeting, at which students and staff have a voice in how SWS is conducted. This democratic component is central to the SWS community. Students who have struggled in mainstream classes due to motivational, personal or behavioral issues have often found success in SWS. The result of the smaller community and the structure of SWS dictates that students take more ownership over their education and participate in the community that they joined by governing its rules and participating in their peers' education. The vast majority of SWS'ers embrace these ideals and are inspired to flourish as learners. The environment breeds curiosity about the world and about the human condition. These are the students to whom I am teaching Biology.

Why Biology I Honor, for these SWS students, at this point in their education? The population does not fit the current method. These students thirst for the connection of Biology to their lives and to the world about which they are so curious. The course that I propose is a drastic realignment, but one that I believe would serve the population. Aspects of what I propose can, and have been, implemented already but the basic structure of the course is still teacher centered.

Project Description: New SWS Biology Curriculum

The project is to adapt and adjust the themes from a *Biology in Society* course into learning experiences for my SWS Biology students. Each week, the installments written are focused on student-directed learning. Students' interests and questions about Biology will drive the sequence and the topics, to some degree, of the course. The installments also are student-centered, meaning that students are engaged with some material, text, lab equipment or their peers as opposed to receiving instruction from the teacher. The installments also incorporate societal themes into their Biological learning. The final product of this project is the beginnings of a SWS Biology curriculum. The new curriculum has structure and organizing ideas but more lessons and activates will need to be added or written to fill out the curriculum.

Installments: Summary and revisions

Each week, I attempted to adapt a theme from the *Biology in Society* course into a learning opportunity for my students. The installments essentially became lesson plans within the new SWS Biology course. Attached, as an appendix, is all the installments written in their

original form and the revisions made to them. Since the installments became the activities for the new course, they needed to be refined before, during and after implementation to meet the needs of the class just like any lesson plan. This is especially true for the type of student-centered class that I am proposing. The focus of this final paper is less on the revision of the installments and more on the synthesis of the individual works into the structure of the new curriculum.

Synthesis of Installments: New SWS Biology Curriculum

The SWS ideals of student empowerment and high academic standards are maintained in the structure of the new course. From the learning in *Biology in Society*, I was exposed to types of learning experiences that I knew would empower and challenge my students. Putting it all together was something I had in mind throughout the installment process but only after thinking systematically did patterns emerge and I start to see the format that I am proposing.

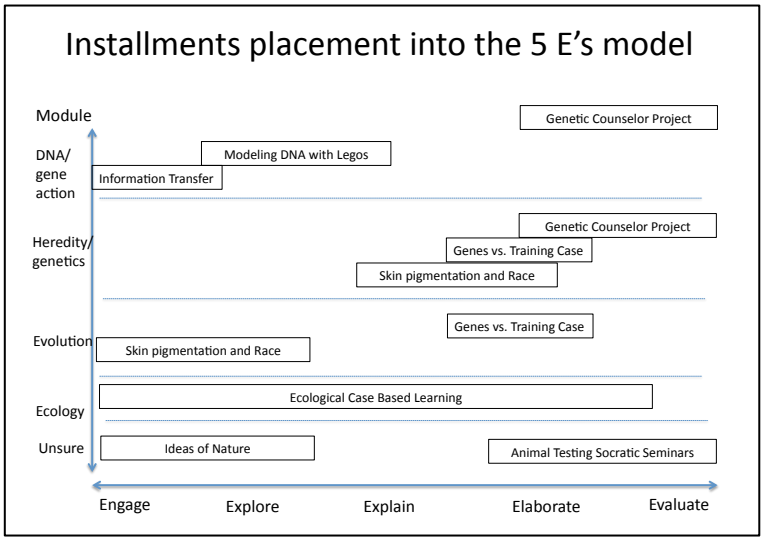

Figure 1: Installments placed into the 5 E learning cycle model. Installments can bridge the type of lesson (see Ideas of Nature installment) and can be used differently in different modules (see skin pigmentation and race)

First, I categorized the installments based on the 5 E model learning cycle (Bybee, 2006) (Figure 1). This allowed me to see how the installments related to each other in sequence. Additionally, it allowed me to see the gaps in the cycles and led me to start to brainstorm what other activities could fill those gaps. Each learning cycle built from the installments is a possible learning module. Clearly there are missing modules that still need developing. The modules are also flexible such that activities within each module can be shuffled and traded based on the class's direction. In Figure 1, the Genetics and Race activity could be used as *elaboration* of genetics/heredity or *engage* in evolution. Therefore, not only will the gaps in each learning cycle need to be filled, but building in redundancy to each module will make them easier to adjust spontaneously. Some installments such as 'ideas of nature' do not neatly fit into a topic theme.

Students engaged in that reading could veer into a wide variety of topics, both biologically and societally rich. But they present a planning challenge since the module would need to be constructed as the students asked questions or they could do pure PBL.

In order to balance individual exploratory learning and student-centered activities, each module has two learning threads (Figure 2). Engage activities inspire questions that launch students into a student-led PBL learning cycle. The thread culminates in the SWS tradition of some form of peer-to-peer learning. The main distinction between the two threads rests in the planning and delivering of material. In the 'student-led PBL', students will research their own questions that arise from *engage* activities and free writing exercises. They will do this in a structure that is common to everyone; however, their research paths could diverge. The 'Student Centered Learning' thread is composed of activities that I plan and facilitate with the students. Activities that I select will hopefully enrich and inform the PBL thread as the module progresses.

The PBL process I envision begins with free writing exercises to develop student questions based on the experience of the *engage* activity. This free write process is followed by a group sharing session in which students briefly describe their free write topics. In this sharing, I hope that students who are stuck will become unstuck or even adopt the learning path of a classmate. Based on the feedback of the students, I will ask them to pick one question that they want to investigate through out the module. Depending on the array of questions, this PBL could be organized into individual investigations or small group investigations. This organization of students remains one of the big unknowns in relation to the sequence and pace of a module. The

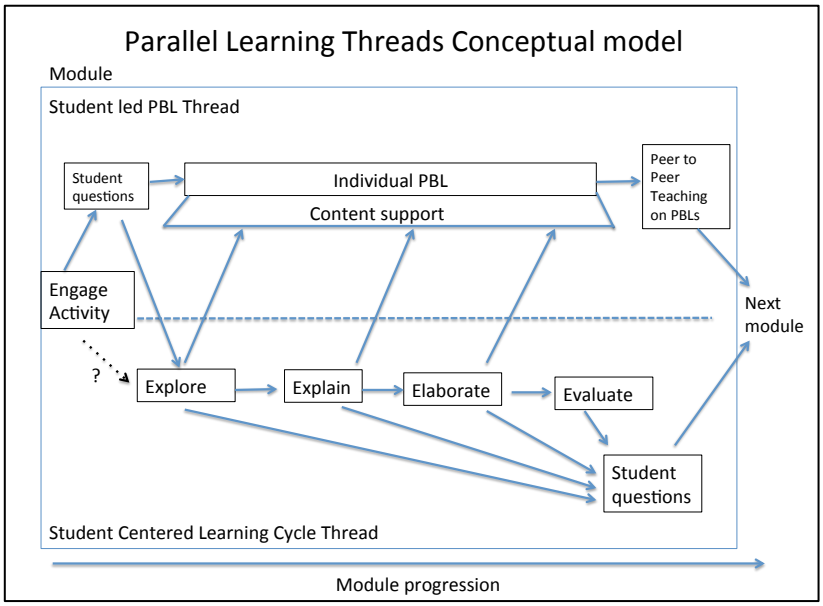

Figure 2: Parallel Learning Threads Module Conceptual Model. This model can flex depending on the module. The PBL thread is emphasized with topics, such as exploring 'ideas of nature' or 'what is life?'. The learning cycle thread will play a larger role in modules that have more of a content grounding, such as DNA.

engage activity, the resulting free write, class response and selection of a single question comprise a sequence that would take approximately 2 class periods. Class period one would be the *engage* activity and the free write exercise. In class period two, students could share and narrow down a single topic and submit that topic to me. Using that information, I could group the students based on common themes and suggest starting points for their research. One still to be determined aspect of this learning is to adopt a method for the students to document their learning and research. There are opportunities here to help students develop research skills and good resources citation habits. At the very beginning of my learning in this crcrth 645 class, I stumbled upon some research that mentioned a software called Coursebook that was designed for this specific purpose. More research is required to determine if that would work for the purposes of this class. In the pervasive social networking world in which we live now, it seem that there must be an application that could record the students' learning process and allow the free and immediate exchange of that process with their peers. The method of documentation of the PBL process could directly feed into the peer-to-peer learning at the end of the PBL. Perhaps each PBL student develops a tumbler page documenting his or her process and relevant research along the way.

The *engage* activity and/or the questions that arise from the engage also initiate the second learning thread around student-centered activities organized into the 5 E model. The installments from this class fit into this student-centered thread since students are engaged with the material and are not receiving direct instruction. Having said that, direct instruction is most likely inevitable over the progression of the year. The learning cycle reinforces the PBL learning by providing content support and

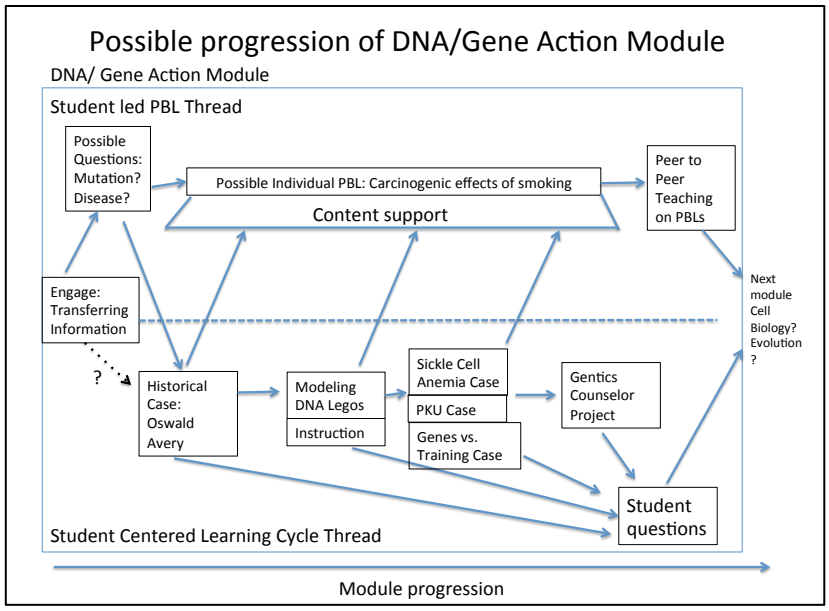

Figure 3: Possible progress of a DNA/Gene Action Module.

presenting more angles for students to consider in their PBL learning. In all cases, the questions that arise from both threads are considered when moving to the next module. Figure 3 presents a possible progression for a DNA/gene action unit. This provides an example of how the module internal structure is flexible. The 'transferring information' *engage* activity provides a good entry into the module but it may not inspire the type of questions that lead students into a rich PBL experience. In this module, the *explore* activity, Historical Case Learning: Oswald Avery and the Search for the transforming factor, could trigger more questions to be researched in a PBL format.

The progression into the next module would come from the new questions that arise in the PBL peer-to-peer teaching and the new questions that come out of the learning cycle. This makes the course both flexible and student-led within the modules, but also as we progress from module to module.

Figures 4 and 5 shows the intersecting processes for the possible progression of the DNA/gene action unit. The content objectives come from the Massachusetts state standards for Life Sciences. The module in its presented form covers all the genetics standards and 3 of 4 inquiry standards (Massachusetts Science and Technology/Engineering Frameworks, 2006)

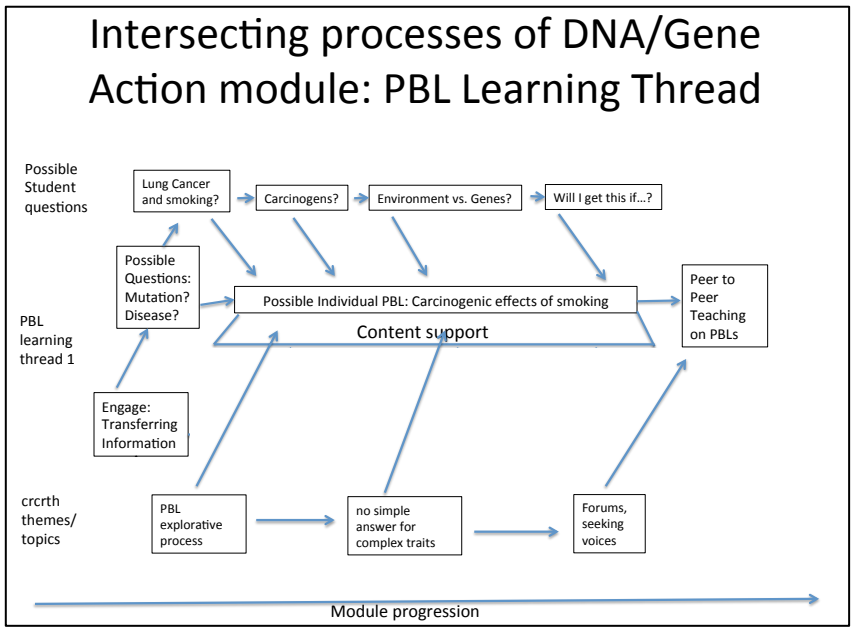

Figure 4: Intersecting processes of the PBL thread of a possible DNA/Gene action module.

The possible student question line is more related to the category of question that students might ask in response to the activities that are a part of the learning cycle thread and as they progress through their BPL. Students are the main confounding variable in all curricular endeavors. It is hard to say with certainty where their minds will take them, which speaks to the point of why do the curriculum in this manner.

The PBL thread offers opportunity to pull in the specific themes of this *Biology in Society* course. This full picture view would be an emphasis of the PBL process. The PBLs will need individual guidance and content support from me as the students do their research. It falls on the teacher to ask questions about their process that nudges them toward an all-encompassing view of their question. If, for example, the student is looking at why people get cancer from asbestos and their PBL research is a review of the cell cycle process, DNA mutation and carcinogens, then that student would be asked questions that get them to think about the historical context of asbestos use, how it affects the different social classes and the economics of asbestos removal. Additionally, the activities in the learning cycle have societal connections, such as the historical cases, and will serve as a form of modeling for the big picture approach to the PBL process. Some of the intersecting processes between the module threads and the course themes can be seen in figures 4 and 5.

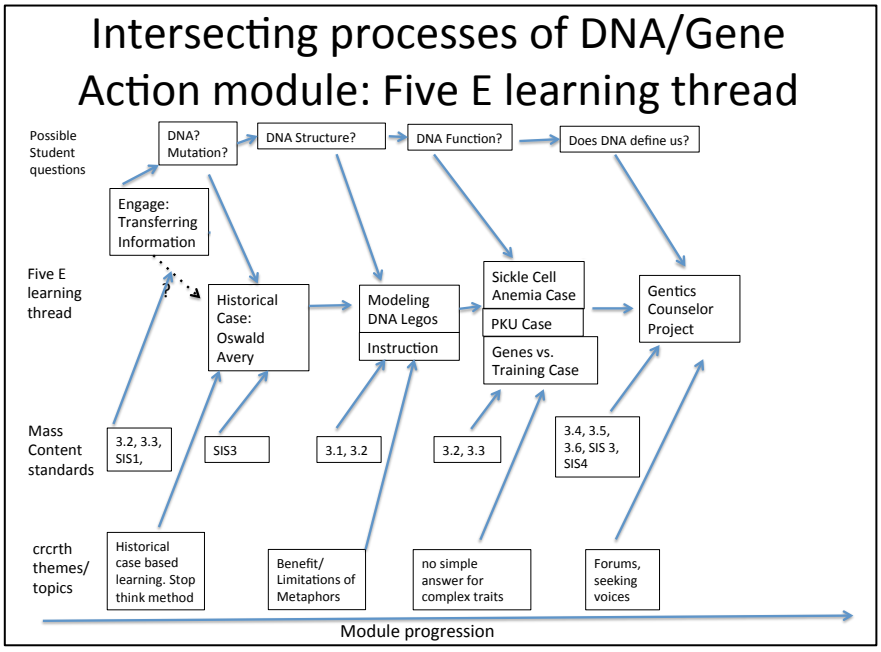

Figure 5: Intersecting processes of the Student-Centered Five E learning cycle for a possible DNA/Gene action module.

Reflection on the process and the outcome

The development of this new SWS Biology curriculum through the process of writing installments has proven to be a good way of stimulating my thinking around the structure of a possible new course. The installment process began and ended with uncertainty as to what the course would look like, but stepping back, looking at the characteristics of the installments, reordering and sorting the installments is what stimulated the structure of the course. The installments themselves need revision and added depth before they can be usable lesson plans. I

find it interesting that in the final synthesis of the installments, I spent very little time on the revision of the installments and mostly on the big picture of the course.

The major struggle I had throughout the installment synthesis process was the balance between the individual student-led PBL format that I wanted to be central to the course and the incorporation of the installments that, while student-centered, are mostly group activities. The duel thread teaching approach is my proposed solution to that balance. The class would truly be an educational experiment and one that I would be equally fascinated and nervous to attempt. When I project in my mind's eye this hypothetical class in my classroom, I am flooded with all the scheduling, space, technological and equipment issues that still need to be resolved. Ultimately, these are the concerns that I have when I think about the class's success. Happily, these are solvable problems and I strongly believe the students are hungry for the type of learning this class could deliver.

The proposed format and characteristics of the installments match my original goals of the project. Why these lessons, for these students? The concentration of intensely curious students in the class requires experiences that allow them to delve into those curiosities and to enrich them with engaging work. The PBL thread, along with the supporting learning cycle, provides ample room for these students to control their learning path in a challenging manner. The flexible path from module to module empowers the students to direct the class while promoting the SWS ideal of collective governance of their learning environment. Why this time? The SWS population is at my doorstep and, as it turns out, this population is intensely curious about the world and how they fit into it. Biology in society is a perfect lens for these juniors in high school to develop understanding.

Where to go from here?

The curriculum requires more work. Aspects of what has been developed are in usable forms and I have started to implement some case-based learning in the classroom already. But the complete curricular package is in its infancy. Planning and developing curriculum in a bubble does not produce final products and is incongruent with the values of BHS and SWS. Where to go from here? The literature. This model is new to me but probably not new to education. I intend to research if similar models exist and if there is any research on their implementation. The 5 E learning cycle model comes from the BSCS organization and is well

documented, but I am unaware if it has been used as a supporting thread for PBL learning (Bybee, 2006). Where to go from here? My colleagues. The BHS science department staff and the SWS staff are full of amazing educators whom I trust to give honest and constructive criticism. Additionally, I participate in a Critical Friends group (CFG) at the high school that consists of teachers. The purpose of the group is to develop reflective practice and to work on individual projects or goals. The work the CFG does is guided by protocols developed by the School Reform Initiative. Taking my new curriculum to this group could help me see new angles on its development. Where to go from here? Start now. The classroom-as-a-laboratory principle could work well with the individual installments. Trying the already developed installments would give me insights into how the entire curriculum would progress.

Struggles I foresee and additional questions

The struggles I foresee are related to changing some of the Saber-tooth curriculum entrenchment that exists today. Wooly-horse clubbing stayed a part of the Paleolithic education because it was thought to develop necessary club coordination skills that could be applied elsewhere. The lecture and note taking passive learning methods of today is often justified because that mirrors college education, to an extent. The paradigm that exists in education today is: work hard study hard, get into Harvard, work harder and study harder, get a good job. To generalize a bit, the educational methods we use perpetuate this paradigm and tell youth that this is necessary to be a good student. What is lost is the actual learning. Youth focus on getting the right answer and not the deep thinking necessary to actually be educated. Youth are anxiety ridden, there is a culture of cheating, the maximum number of AP classes are crammed into the schedule and grades are watched closely and override the learning objectives of the lessons. That is, perhaps, the negative view of what is happening today, and changing the conversation is never easy. It creates work in an already overflowing teacher schedule. There is no time for this type of curricular development in the school day, week or year. This is one main struggle I see in the full development and implementation of the course. BHS has two innovative curriculums in place, Living By Chemistry and BSCS Biology, but, over time, both have drifted back toward more traditional methods due to the common teacher pressures of planning and assessment. Week-to-week planning for a fully student-led course is difficult. Matching the progression of an unpredictable PBL process and open-ended student-centered activities into a 50-minute class

schedule that meets four times a week is one practical hurdle that many will point to as insurmountable. Additionally, supporting students with 504s and IEPs in a less traditional classroom is often incompatible with the way the education plans are written since those plans are part of the traditional paradigm. Accommodations often say, '50% extra time for assessments' and 'graphic organizers given for notes'. Both of these accommodations could have no application in a particular module. The top down implementation of standardized tests, like the MCAS, also puts educators on their heels when considering major curricular shifts. The first question from the panel that reviews new courses will be related to content coverage since, in the current paradigm, it is viewed as the necessary component to success on many standardized tests, and the panel is not necessarily wrong. These tests are typically content-narrow and devoid of critical thinking. All you need is a class that presents the facts and teaches how to write an essay. Why shift the approach if the measures that will govern if schools stay open or if teachers keep their jobs is a content-narrow test? This is the focus of gatekeepers and not relevance to the education of the students. We are still clubbing woolly horses.

Having said all that, I sound jaded; however, the possibility of doing this course at BHS is high because it is targeted at the SWS population. The questions that are still in my mind are centered on the logistical challenges and collecting the input necessary to refine the course into something that could be presented to the review committee at the high school. I also wonder about implementing a variation of the course as a second year Biology class for seniors. This could also provide an alternative for student on their senior paper, which is a graduation requirement and often has a literature focus. Discussions about changing the senior paper format have already started within SWS. There also are collections of SWS seminar courses that meet once weekly that could provide a stepping-stone into full implementation of the course. Maybe the aspects of the curriculum could be adjusted into a seminar and the experiences could guide revisions for the full curriculum. The SWS community provides an opportunity and serves as a crack in traditional educational paradigm. It is a crack into which I want to slip a new SWS Biology course.

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Appendix: Installments

Initial Description – September 18th 2012

My semester long project will be based around adapting the tools and themes from this class to a new Biology curriculum at Brookline High School (BHS) for the School Within a School program (SWS). The SWS program at BHS was established in the 1969 to provide an alternative to the mainstream school. Like many alternative programs SWS was established to serve a particular student population at that time. Many students at that time were looking to buck the trend of teacher-centered classrooms and wanted to have a voice in the way their school would be run. Today that central value is preserved and a 3 part mission has been added 1) high academic standards 2) small caring school community and 3) social justice threads in curriculum and school community. This completely voluntary program has proven to be attractive to students that have a built in curiosity about the world around them and how humans impact that world. SWS is also attractive to students that have struggled in more rigid learning environments, something that I do not think is disconnected from the former. This population is ripe for classroom experiences that allow students to direct their learning. This project is meaningful to me because these are my students and I want to serve them well and because I am interested in try something new and hopefully inspiring. I am a new teacher to SWS but not to BHS. SWS is mine to develop and I am asking the age-old educator question, ' why this curriculum, at this time, for these students'. Additionally the concept of 'built in curiosity' is something I have found all students have if the distractions are moved to the side and the right questions are asked. One great teacher trick is getting kids to move those distractions aside. I propose this SWS group as a good starting point because it is more of a safe space for me. Since kids have signed up to have a more fluid, less traditional classroom I submit that this population

will allow me to do more and maybe hone a few more tricks for all my students and find questions that speak to all groups.

My project would be based on taking the tools of creative and critical thinking from this course and explore how they could be used to teach first year biology principles. In addition to adapting the tools and themes I would like to come up with the critical questions that could spark the type of learning we have discussed. I am interested in exploring the depth and breadth of particular tools to see if they will sufficiently meet the teaching standards (i.e. Massachusetts Science standards and/or Common Core Curriculum standards) that my courses need to address. I am also interested in exploring classroom organizational techniques around PBL and other tools so that I could implement the tools with full classes of students.

One question I still have is how do I guide the learning of 24 (my average class size) different learning paths inspired by one ill-defined case? Given the constraints of the class time, resources and class size, how one uses a tool may be just as important as if the tool is used at all. In my early research on the web related to PBL in the high school curriculum I have found that this has been attempted and there is even some software, CaseBook, hat has been used to organize students around the questions they ask. This will be an area of continued research and I am hopeful this will help me answer some of my logistical questions around class size and time at learning. In regard to developing the ill-defined questions that inspire the process one resource will be the case study database at the University of Buffalo. These cases are often specific and do not offer much room for the students to wander. I wonder if they could be reworked to broaden the possibilities, much like the Embryo case that was presented last week in session 2.

Ideas of Nature – September 23rd 2012

Interpreting ideas of nature as ideas of society has a lot of potential in the SWS Biology class that I envision. The student population that self selects for SWS tends to want to know how the things that they learn in school fit into the world. Continuing with the idea of adjusting the tools from this class into a high school biology curriculum, I am interested in how I can use this concept of nature to launch students into some area of inquiry and content. The Williams text would be too challenging for the vast majority of my students. The first hurdle of bringing this to my students would be to find a text that is accessible. Having a text would be a great way to

start since it would align with a SWS tradition in History and English. I think this is a solvable problem even though my immediate efforts did not produce anything. Additionally there is a tradition in the SWS English classes of developing idea about self (i.e. adolescence, gender, etc..) into written works that are extremely personal and honest through free writing, reflection, revision and class discussion. I am very interested in bringing these SWS traditions into my Biology class. The close reading of text, free writing about ideas of nature and the class discussion that would follow could be a perfect way to start a unit of study (or to nudge them towards a topic that I want them to explore. I am still debating if the course should have units of study or if it would be a more open structure that could follow the students interests.) Depending on the nature and number of texts that could start this discussion, I imagine two possible scenarios. Multiple texts that take different views on nature throughout history could be great material for a Socratic seminar. The SWS population is familiar with this method from their history classes. If there is one but more difficult text, possibly Williams, as opposed to the multiple texts then a text analysis jigsaw could work nicely. Chop up the text based on length, theme and/or difficulty and challenge the students to explain their section to their classmates.

The content that could follow this discussion of nature should flow from their ideas of nature. With the idea of nudging them towards content, I would want them to explore the idea of what is considered natural. I am specifically thinking about how this connects to the foods we eat. There is a huge market push for natural foods, organic foods, non-GMO foods but what is the food industry standard of natural? This could be interesting to explore and along the way teach biochemistry. Maybe even allow the ideas of nature to lead to a PBL on this exact topic of the substances that make up our food, the biochemical molecules (i.e. my content). The concept, for example, of my students seeking out the difference in structure of a saturated, unsaturated and/or trans fat, so that they can understand larger questions they have about how food fits in to their schema of what is natural is thrilling.

The other obvious nudge toward a content area would be around mans place in nature or out of nature. Mans impact on nature, parto or seprato, surely will come up when discussing ideas of nature. There are a number of PBL experiences and/or case studies that could be targeted towards the research interests of the students here. Content wise these inquiries could delve into toxicology, conservation, ecology and evolution. The possibilities seem almost endless and really could take over the school year. Here is one case study that I have used in the

past that jumped to mind. It is called 'My Brothers Keeper', it explores kin selection in Belding squirrels. http://sciencecases.lib.buffalo.edu/cs/collection/detail.asp?case_id=557&id=557

The challenge to all of this that persists in my mind is that every student in my class needs to get to that question about the chemical structure of fats and not just the ones that venture down the pathway of wondering about margarine. Conversely not every student will explore questions about nepotism in the animal kingdom when wondering about 'human nature' and to compound it all kin selection is certainly not on the list of state science standards. Their needs to be some component of this new class that allows the students to share the vital information (i.e. content) they learn along the way. I have a fuzzy idea about end of unit capstone projects that condense each student's findings into some presentation and I could fill in the gaps or stress the important stuff as needed, but I am not sure if I like that idea yet.

Natural Selection as a Metaphor – October 10th 2012

This sessions topic just like last weeks I found difficult to blend with my plan of writing a new biology curriculum for my SWS population of students. In one way I could go at this head on and simply do a close reading of Origin of Species with my students and use it as a primary source to teach natural selection. The text would be accessible enough with guidance and with some scaffold graphic organizer companion that aims the students at the things I want them to see. The secondary way of approaching the O of S text that you posted under the cases link gets at the why Darwin was presenting the argument but I think for my purposes it would be more about 'what is the argument?' This could be an interesting exercise to insert into a longer module of study around the development of the theory of evolution. The purpose being two fold 1) to teach evolution in a historical context progressing to our modern take on evolution and 2) to illustrate the refinement of scientific theory as new observations are being made. Thus laying out the body evidence for evolution bit by bit.

Since evolution has its tentacles stretching into every other area of biology, I could see this as a module that could start a school year or end a school year. The start of the year scenario could allow students to ask questions about the material of inheritance and take us towards DNA and genetics or toward organism's interactions with each other and their surroundings leading us to ecology. If the module came at the end of the year it could be a great way to tie together the learning we completed throughout the year.

I have to admit that doing teaching evolution along the linear path of time does not excite me as much as some of the other ideas that I have come up with and it makes it hard to run with it. Evolution in the light of inheritance and DNA makes so much more sense, I wonder if denying my students access to it as I march through time would hamper their understanding, especially, if the module came early in the year before the story of genetics/DNA. In addition to that, I find it virtually impossible to talk an entire year about the living world without mentioning evolution. I have to think that the students would run into it along the way as their questions and inquiries drive the curriculum.

Maybe this is the key point; evolution would be studied when it is relevant to the student's questions about the world.

Information Transfer – Resubmit of above metaphors installment – October 23rd 2012

*Peter Taylor Comments - The challenge is to connect your project with the themes of the class, which were not evolutionary theory per se, but the multiple layers to support an argument. Alternatively, you might focus on any one of these layers, e.g., how scientists use (or abuse) analogies, e.g., genetic **code**, **blueprint**, evolutionary progress (http://www.tim-taylor.com/papers/thesis/html/node21.html). As I read your installment, it dwells on when and how to bring evolution into your course -- a valid question, but not much connected with CCT645. If I'm missing something in your thinking, please clarify. Either way, revise & resubmit by 10/24.*

You did not miss anything in my thinking. I agree when I look back on my installment, I grabbed the idea of teaching evolution and ran with it and left behind the multiple layers of argument in presenting a scientific idea. I think that I got onto the idea because I would be focusing on the analogies that Darwin uses as one mechanism to teach evolution, much the same way Darwin did in Origin of Species for his readers. But, to your point this is exactly what we did in class and not much of a connection to the theme of the lesson. On to my second try…..

Your suggestion about analyzing an analogy sparked a memory about comparing DNA's function of storing and transferring information to offspring to the game of telephone. The activity comes from the BSCS: A Human Approach Activity (http://www.bscs.org/bscs-biology-human-approach). The activity is an engage activity that is focused on getting students to think about information transfer and the methods that one can employ to improve the quality of information transfer. The activity is given well before students are taught about the structure or function of DNA. Having said that, most juniors in high school come to the topic with a working understanding of what DNA's function but not understanding the mechanisms.

The activity requires students to sit in two large half circles and play telephone. Teachers stands at the split of the two half circles and hands small slips of paper to the students. First

students are asked to speak the words to their neighbor and the message travels around to the end of the circle and if final student writes down the message. The two half circles compete to give some urgency to the process.

The activity continues with multiple variations. Coherent sentences are used in addition nonsensical sentences, random letter combinations and number, letter and symbol combinations. Students can be asked to try different methods of transference to increase accuracy. Multiple trials are done with the variations above, with the students comparing the final message to initial message each time. The conversation edges toward the types of messages that are easy to transfer and the methods that led to accuracy.

The analogy also can be a good time to introduce them to mutation. Mutation clearly will happen randomly and small changes to the message at each step can lead to big changes in the end. There is also 'environmentally' caused mutations when the teacher slips a note to one of the student's part way through the circle that instructs her to change a specific word. This usually works well once the students have refined their process to be constantly accurate. It also works well if the word that is changed converts a sentence that makes sense into one that then makes no sense.

This activity would work well with my population of students in that it draws on there prior knowledge and gives them multiple analogies to recall as DNA and it's related topics are covered over the following week.

Blueprint or Map – October 23rd 2012

Mendelian genetics has a place in all high school biology curricula but it often creates the sense in students that all phenotype come in pairs. Mendel's peas give the impression that peas are yellow or green, smooth or wrinkled. The subsection of the garden pea genome that Mendel studied does seem to be a blueprint for the physical characteristics that are displayed in that pea. The blueprint metaphor while leaving some of the common teaching vernacular still persists in many other locations. The result is that it shows up in my class every year when I ask the very simple question, 'tell me something you already know about DNA?' It is such an attractive metaphor because of it simplicity and because there are several examples, especially in Mendelian genetics where it seems to be spot on. The analogy starts to unwind when looking at polygenic traits and unwinds further when adding in the environmental influences on phenotype.

Metaphor can be a great tool in teaching to help students understand something in the moment but often-carful dissection of the metaphor will soon show its faults. Understanding those faults in the metaphor can be an important step in understanding the principle. It can also be a good assessment tool for determining the level of a students understanding. When asking a student 'what is DNA?', if the only answer that comes back is the restatement of the metaphor their understanding of DNA most likely is only as deep as the limitations in that metaphor. But if a student can say the metaphor, DNA is a map, and then explains why the metaphor works, then you know the metaphor is helping them understand DNA. Even better would be if they could explain the metaphor and also point out the limitations.

This type of work with my students could help when using models in the classroom. Models are basically just physically tangible metaphors and they have limits too. When studying DNA I have used Lego modeling kits that do a good job of displaying base pairing and DNA replication. The model is limited in explaining aspects of DNA like the formation of chromatin or gene expression. This activity could benefit from my students explaining the model in terms of what it does well and what it does poorly in representing DNA as a whole.

This is what I want to work on with my students. Helping students to see the metaphors in biology for what they are, limited explanations for complex concepts. I do not envision this as a single lesson or teaching module but more of a thread through out the class. For each metaphor take the step back and have them explain why it words, where is the connection between metaphor and concept, then as their understanding grows have them try to chip away at the metaphor to look for its flaws. This method could also reinvigorate old metaphors. Students could use their knowledge of DNA to explain why the 'blueprint' metaphor does not fit our current understanding of genomes and in the process roll back some misconceptions about genetic determinism. (Every year I hear, 'my uncle had cancer does that mean I will get cancer?') They could also look at the lock-and-key model of enzyme function and explain why we have moved to the induced-fit model.

Historical Case Based Learning - October 24th 2012

When I envision the classroom experience of the SWS curriculum I am trying to mold I have often thought about students doing case based work. I have seen how case based work allows students the space required to think creatively but also provides the structure necessary to narrow

in on a particular topic. The case from this week was a natural fit for the SWS curriculum and meshes with all the missions of the SWS program (community of caring learners, high academic standards, and justice). Also by using multiple cases that teach similar topics I could offer students choice. Then by doing student-teaching-student groupings I could allow the students to see the depth and breadth of far reaching topics, like ecology. Ecology also is a great area to relate to causality. Many of the environmental issues we see are caused by tangled webs of variables and it can be hard to boil it down to simple answers. The case based learning could also help students see this complexity by allowing them to delve into real situations.

The three cases I have picked are all from the University of Buffalo Case Study database and the all represent real environmental situations that have complex answers. Kermit to Kermette? Does the Herbicide Atrazine Feminize Male Frogs? This case works with a commonly used herbicide that is suspected of feminizing frogs. The case presents data that is conflicting from two different studies. It addresses the biological mechanisms for hormonal sex determination but also brings to light the different experimental methods of the two studies. The case also brings up the funding sources of the two studies and asks the students to consider the conclusions of the studies based on the researchers bias, if any. The second case is called Search for the Missing Sea Otters: An Ecological Detective Story. This case looks a complex feeding interactions in a pacific coast marine environment and challenges students to find out why otter populations are dwindling. It also brings up human impact on environments and keystone species. The third study is called Disappearing Marine Iguanas: A Case of Population Collapse. This case also looks at the decline of a population but the story takes a different path and relates to abiotic changes in the environment that manifest in changes to the food chains.

These three cases all represent complex interactions in the environment and touch on different areas of ecology and physiology. Students would used the cases to learn about the specific topics that the case contains but also help them gain perspective on the complex interactions that lead to complex explanations. Students would then use this knowledge to teach their case to the remainder of the class, so that they could broaden there understanding of ecological principles. (Example: The Sea Otter experts would be teaching their peers about keystone species.) Since all students went through the process of doing cases and seeing an example of complex interaction they could use that experience in helping their understanding of different cases.

Additionally, I am interested in adding in the historical piece to this process. Many of the cases that I am familiar with do not have the far-reaching historical perspective of the beriberi case that we just did in class. I am interested in developing a case around history of DNA as the molecule of inheritance using the works of Fredrick Griffith's work with *Streptococcus pneumonia*, Oswald Avery's extension on Griffith's work, and Alfred Hershy and Marth Chases work with bacteriophages. The idea is attractive to me and while I know about their experiments, I do not know about the history of them as researchers or individuals and I am unaware of the level of collaboration.

Kermit Case

http://sciencecases.lib.buffalo.edu/cs/collection/detail.asp?case_id=189&id=189

Otter Case

http://sciencecases.lib.buffalo.edu/cs/collection/detail.asp?case_id=167&id=167

Iguana Case

http://www.sciencecases.org/iguanas/iguanas.asp

Taking Positions – October 29th 2012

Last weeks exercise of taking the positions of two opposing views sparked my interest. This format could be useful for many different topics in my new SWS Biology course. Talking about ethical decision-making in Biology is an essential part of high school Biology classes. Often student have strong reaction to topics like stem cell research or testing on animals but rarely do they have the full picture yet. This is one area that is truly relevant to the student but largely over looked in standard curricula. Additionally doing inquiries around bioethics would be a great way to get students asking questions that could drive their leaning, which is one of threads that I want through out the course.

To adjust this weeks theme of taking on opposing view points and debating the issue, I have picked animal testing as the bioethical topic but many topics could be adjusted to this theme. The students would first be exposed to bioethics using the Exploring Bioethics: NIH Curriculum supplement. This resource is a good way for students to be exposed to the field of ethics and to create the structure for the debate. The supplement also helps establishing norms on how to conduct a civilized discussion around issues that cause some people to become heated.

Then I would expose students to a variety of different resources on the topic of animal testing. I have linked several articles below that I am considering giving students. (I still need to vet the articles more thoroughly before giving them to students.) I would ask students about the author's views on animal testing and about what type of evidence is presented to make the case. Does author give a viewpoint or is it mostly informational? If the author does not give a viewpoint does the author adequately present both sides of the case? I want the students to be learning about the issue of animal testing but also thinking about the sources they are reading and the tone or purpose of the author. Students would also be asked to do their own research on the topic.

The students would be asked to write a position and to support their reasoning with evidence from the given reading and from other research. The culminating event of this exercise would be a series of Socratic seminars in class that ask students to present their case for or against animal testing. Groups would be created based on their positions on the topic. The class would be broken into several smaller groups so that the conversations would be more intimate and allow for participation from everyone. There would also be a second round of arguments. Groups would rotate and the students would have to argue the opposite point of view. Full class discussion would follow around how ideas and assumptions were challenged throughout the process.

The challenges here relate do classroom management. Passions in young people can overflow in ways that drown out the soft-spoken student. Since I am purposely poking at those passions I need to make sure that it is in a way that allows all of my student's space to speak. The SWS culture claims to give voice to all its members, so I will need to pull that ideal into this activity. Smaller groups, the introduction to ethics and having students argue the opposite view are all in effort to make sure everyone gets the chance to challenge their classmates to think deeper and in different ways.

Exploring Bioethics. NIH Curriculum Supplement Series Grades 9-12.
http://science.education.nih.gov/supplements/nih9/bioethics/default.htm

Animal Welfare Act – US Legislation that governs the use of animals in testing.
http://www.nal.usda.gov/awic/pubs/Legislat/awabrief.shtml

National Research Council. *Guide for the Care and Use of Laboratory Animals* . Washington, DC: The National Academies Press, 1996.
http://www.nap.edu/catalog.php?record_id=5140 - toc

Alternatives to animal testing: current status and future perspectives
Archives of Toxicology 2011 Augus: 85(8): 841-858

Published online201 May 24.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3149673/

PETA – Animal Testing 101
http://www.peta.org/issues/animals-used-for-experimentation/animal-testing-101.aspx

Wilson, Scott. Animals and Ethics. Internet Encyclopedia of Philosophy. January 13, 2010
http://www.iep.utm.edu/anim-eth/

Blakemore, Collin. Should we test on animals? Yes. The Telegraph. October 28 2008.
http://www.telegraph.co.uk/science/science-news/3353960/Should-we-experiment-on-animals-Yes.html

Feder, Barnaby. Saving the Animals: New Ways to test products. New York Times. September 12, 2007
http://www.nytimes.com/2007/09/12/technology/techspecial/12animal.html?pagewanted=all&_r=0

Taking Positions Resubmit – November 14th 2012

Peter Taylor Comments in italics. 11/12 At first this seems like a similar case to the Lewontin-Jensen exchange, except that their exchange centers on what science shows, not on how one feels about and values animals.

Agreed the Lewontin-Jensen exchange was about interpretation of the science and certainly looking at the ethical treatment of animals is about values. When I picked this topic I was stretching the theme into ethics and away from interpretation of the science. Perhaps this is to far of a stretch on the theme of the week.

*Yes, in both cases, you want reasoned exchanges and for people to be ready to concede when the evidence or argument of the other side is right, but that's hard to do on values. I suspect that the debate you propose would, ironically, reinforce the view that disputes all come down to values and so we can't say one side is right and one is wrong. I suspect that this is **not** what you want them to think about **science**, no?.*

I am pushing back (with some tweaks) on this one. I do not think the debate that I envision would actually do this. Perhaps more explanation is in order. One important aspect of this activity with the students would be first to frame the ethical issue. The NIH curriculum does this well. It parses out the difference between scientific, legal, preference and ethical questions. What I truly hope is that the activity would help reveal what assumptions and biases that people bring into a debate. Usually students have kneejerk 'no' responses to the question, 'should scientists test on animals?' The non-kneejerk response (yes or no) to that question is complex and brings up scientific questions like 1) what does science say about the necessity and/or impact of testing on animals? 2) Do animals experience fear or pain? 3) Are there sufficient replacement technologies? and so on. The students may be driven to the legal side of the issue

and explore what laws are currently in place. This is the exploration that I am interested in and the debate is the product of their informed but likely varying positions. I do not want or need them to come to collective conclusions about the ethical treatment of animals but I hope the research they do and the debate that ensues would illustrate what are the scientific questions surrounding use of animals and how it can or cannot help us understand both sides of the issue.

In this vein there is space for both of the suggestions that you give below and also reveals that the students will need to be helped along the way. There will need to be some level of scaffolding through the research process for the students who do not have or care to have a position. Exposing them to aspects of animal welfare and/or asking them to take on the position of an organization like PETA would help grease the wheels or help them see an area of the issue that they have not yet incorporated into their position.

I do realize that this activity effectiveness is teetering on an edge of a knife. On more than one occasion just one vocal yet moderately informed strongly opinionated person can change the face of a debate. Additionally if the students value statements about animal testing are not accompanied by what science tells (or doesn't tell) us about animal testing the debate will not have its intended purpose. Perhaps the addition of a moderator to the debates could help guide the students into meaningful conversation.

Two ways to get around this problem: 1) Introduce them to the field of lab animal welfare studies (e.g., http://ethos.no.sapo.pt/peop.html), which is a similar move to my saying, as a criticism of both Lewontin & Jensen, that we need to learn about the successes and limits of efforts to boost "IQ" (or academic achievement), or reduce the gap between averages for racially defined groups. See if some whose values seemed to be firmly on one side or on the other now see a way to move into the center. Should PETA oppose this line of research or what?; 2) Ask them to examine changes in the ways animals are treated as science becomes linked with industrial production, thus expanding the issue from values to the politics and economics of industry and R&D.
Please digest my comments and see if that leads to any revisions. Aim to submit these by 11/19.

Original installment 10/29/12

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rarely do they have the full picture yet. This is one area that is truly relevant to the student but largely over looked in standard curricula. Additionally doing inquiries around bioethics would be a great way to get students asking questions that could drive their leaning, which is one of threads that I want through out the course.

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activity. Smaller groups, the introduction to ethics and having students argue the opposite view are all in effort to make sure everyone gets the chance to challenge their classmates to think deeper and in different ways.

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http://www.telegraph.co.uk/science/science-news/3353960/Should-we-experiment-on-animals-Yes.html

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Genes vs. Training – November 8th 2012

In this installment I focused on the theme of incorrectly looking for simple genetic answers in complex traits. I think that discussing complex gene and environment interaction is an important part of explaining our current understanding of how our genes shape who we are. As I mentioned in my previous posts the idea of a genetic blueprint and the deterministic behaviors of genes is apparent in the misconceptions that students bring to first year biology class. It is tempting to reduce complex issues down to simple answers but ultimately this does a disservice to the students because many, many phenotypes that are connected to genes are also strongly influenced by the environment.

The example that I propose using with my class centers on the role of genes (talent) and environment (training) in athletic performance. Specifically we will look at endurance running performances. The Africans have dominated the top tier of elite runners ever since Abebe Bikila

won the 1960 Rome Marathon, barefoot no less. He came back to win again in 1964 after getting out is appendix just 40 days prior! Consequently the years of African dominance has raised the question; is there any innate genetic advantage of the African runner or is it their culture of running. Many in Ethiopia and Kenya will run to and from work/school. The geography is at altitude; many have wondered about what effect this has on training. Endurance running is also valued highly in these societies.

There are many interesting questions to raise with the students around this topic. How do you define talent in this situation, is talent only genetic? What encompasses the endurance athlete's environment, is it only training? What scientific work has been done around the genetic components of athletic performance? What scientific work has been done around the importance of training and practice? Does the science sufficiently answer these questions? These questions lead us towards doing biology around not only genetics and physiology but also Anders Ericsson work on the 10,000 hour concept.

The learning would start with an article called 'Why we're the best' by Oliver Poole from the London Evening Standard. The article brings up some of the main points of the issue and will get the students into the mode of asking some of the question listed above. Then, my favorite science geek blog, The Science of Sport written mostly by Dr. Ross Tucker an exercise physiologist has 3 great posts that I will use to frame the genes vs training issue as it relates to athletic performance. All three posts are accessible to high school students and do a good job of looking at the science on both sides of issue. The first post called, 'Genes vs Training: The secrets of success', Dr. Tucker discusses an Poole article and dissects the points more. The next post called, 'Genes and performances: Why some are more equal than others', gets in to the complexity involved in the genetic component of performance. With these two posts I plan on incorporating the technique from the beriberi case where I ask the students to read a section of the post and then stop and think and respond. The responses to the think questions could then become discussion points if the activity was being done during class time or homework assignments for that night. The final post called, 'Dear Anders Ericsson….a request on behalf of sports science to stop telling people that the world is flat' is Dr. Tucker's rebuttal of Ericsson's "mistruths" about the 10,000 hours of practice being the major contributor to athletic performance. For this last post I will adopt the argument/counter argument method that we used

when analyzing the Lewonton-Jenson exchanges. (I immediately thought of this post when I started reading the Lewontin-Jenson exchanges.) Links to the article and the blog posts below.

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http://www.standard.co.uk/olympics/olympic-news/why-were-the-best-6429916.html

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Genes and performances: Why some are more equal than others
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Dear Anders Ericsson….a request on behalf of sports science to stop telling people that the world is flat
http://www.sportsscientists.com/search?q=Anders+Ericsson

Genes vs. Training Resubmit – November 27th 2012

Below are my additional thoughts based on the comments you gave me but I do not know if the constitute a full revision.

Peter Taylor Comments 11/12. *This case fits well the methods of stop & think and of dissect opposing arguments. As I mentioned in class, one issue that should also be addressed is that of stereotyping based on the extreme or elite cases. If it is the case that more of the elite in some activity come from a defined group and that this group may share more genes and more environmental factors than randomly selected people from the human population, that does not imply that any person chosen from that group will a) be better on average at the activity or b) become better than average if they focus on improving in that activity. This can be simply illustrated with two overlapping bell curves, in which one has a lower mean but also a lower height and longer tail. This seems to be the case with more boys showing precocious high mathematical performance. Ask your students to stop and think about the implications. And about the implications of this being not emphasized by people who argue about genes versus training. You might include Larry Summers's comment as Harvard president about men vs women in science, for which he was widely criticized.*

The above is an interesting aspect to include into the activity. I wonder how to integrate it into the structure that I have for the students. It could be a good way to cap the lesson (or series of lessons) by doing exactly what you suggest, showing the students the two overlapping but differently shaped bell curves. I think it would be challenging to do this with runner populations because 1) I am not sure what populations to compare and 2) I am not sure that I could dig up the actual data and 3) what 'activity' am I comparing. It might be better to take a step back after digging into the elite runner training vs. genes discussion and compare to another elite example for which there is data. I would be interested to see the data on the 'boy math' data you mention.

You should also include stop and think (for yourself as well as for the students) on the simple equation genes=talent; environment = training. Clearly no new born can run a marathon, so talent is not inborn, but has to be developed and all humans develop in an environment.

Equating genes with talent and environment with training is the exact over simplification that I was hoping to address with my students. I think this is the misconception and Tucker points to the conversation being to weighted to running success related to hard work and practice. The developmental aspect of talent that you mention is something that I want students to bring up as they look closely at what constitutes the environment of young runner growing up in Ethiopia/Kenya.

So what does one has to do to factor out environment's effects to get at genetic effects? (The answer might include raise many sets of identical twins separately in randomly chosen families/environments, so whatever similarity they have is due to their shared genes. The answer of Tucker is that: a) genetic [inborn] potential/limits ***must*** *be there even though there are too many genes involved for us to be able to say much more* ***yet*** *[but take note of the VO2max study]; and b) don't expect to find that environmental factors count explain everything.)*

Original Installment below

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Genetic Counselor Project – November 14th 2012

The array of disorders that have some connection to heredity and the complexity that comes with each can be an overwhelming topic for high school students. Students often have heard of the disorders or have some connection to a person with a disorder. In their effort to sort through the information feelings and emotions can surface. In this installment I will use the theme of creating a forum to help my students sift through the wide array of disorders and their varying characteristics.

The students will become both the presenters and audience in a poster session style forum. Each pair of students will research the genetic counseling profession and one disorder. Students will be given some starting points (links below) and required components (ex. symptoms, frequency in the population statistics, modes of transmission, prognosis, etc.) for their research but will be allowed to expand from there. From their findings students will write up a detailed fictional case study of a family or individual that is being counseled on the disorder that they researched. The fictional account can include aspects of real cases that they find through their research. The students will then create a poster that outlines the case and essential information about the disorder and a brief presentation of the case. The poster session will be the culminating event for the project. The pair of students will take turns; one presents while the other visits their peers posters and learns about the other disorders and cases. Teachers and other staff members will also be invited to the session to give is a more robust feel and bring some formality to the process.

The project is aimed at getting students to see the wide variety of disorders and also to provide the human aspect through the fictional cases. Additionally students will need to have some guidance or inspiration as the visit each poster to stimulate discussion about the case and/or the disorder. Giving students free rein to just explore the session can lead to laziness and on the

other hand giving them guiding questions can lead to students just checking off the boxes without having meaningful interaction at each poster. Having other adults in the session would improve this but ultimately I want my students to get there on their own.

Genes and disease: Genetic dictionary listing many disorders
http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=gnd.TOC&depth=2

Info on certain genetic diseases
www.noah-health.org/en/genetic/

www.kumc.edu/gec/support/

www.genome.gov/10001204

health.nih.gov/result.asp/281

Genetics counseling info
http://www.salary.com/careers/layouthtmls/crel_display_Cat10_Ser138_Par238.html

http://www.kidshealth.org/parent/pregnancy_newborn/medical_problems/genetic_counseling.html

gslc.genetics.utah.edu/units/disorders/whataregd/

Genetics Counselor Project Resubmit – November 27th 2012

Peter Taylor Comments (no date) *The Rapp article invited us to look at the development of genetic screening from the perspective that there are many un(der)heard voices. In your class activity, the focus is on the voice of the genetic counselor who provides the parents with information about the biology of the condition. Can you think of a way to use the same poster format but get the students to look outside that focus? Not only is the significant variation in the outcome given the same result of a genetic test, but there is significant variation—depending on how other people act—in the life of the child if not aborted—recall my story about the friend with MD. I once read a Canadian study that showed views of how drastic the implications are of a genetic condition go from genetic researchers to doctors to genetic counselors to families, with the families seeing the condition as less drastic. If your students just learn the biology, you'll be biasing them towards the position of the researchers given that the activity won't provide them any of the social context in which the condition is experienced, no?*
Can you revise this activity to bring, in short, a bit more society back into (or around) the biology?

The addition of more stakeholder voices that relate to the individual disorder cases certainly would bring more depth to this activity and would also pull in the societal context of the disorder. I do see how having the information presented only from the genetic counselors point of view narrows an activity, which could be a much richer experience. The scope of the poster sessions and the assignment itself could be broadened to not only be informative but to

focus on the background of the case the students write and report on. Increasing the size of the groups to 4 (or more) and adjusting the assignment so that each group member takes on the role of one stakeholder in the case would bring more context to the disorder.

Collectively the group members could research the Biology of the disorder and formulate that into a component of the poster. Also collectively the group could create the basic outline for a fictional case of someone with the disorder. Then each member could adopt a specific role in the case. Depending on the case the group creates the stakeholders would vary, examples include, a pregnant woman, the father to be (or not to be), doctor, genetic counselor, person with the disorder, researcher running a clinical trial, etc…. The group members would have to integrate the perspective of their adopted stakeholder into the fictional case they write. This opens the door to doing some timeline variant of intersecting processes activities we have been working with. This could be an interesting visual way to display the timeline of the fictional case they create and to see how the different stakeholders contributed to the case.

Some adjustments would have to be made to the poster presentation format to make these changes work. The presentations are longer, more in-depth and every group member will play a different role. Each group member would have to be at his or her poster ready with a Biology description of the disorder but also ready to discuss the disorder from the perspective of the stakeholder role they adopted. I now envision several poster session days with 2 or 3 groups presenting each day in a round robin format.

Original installment

The array of disorders that have some connection to heredity and the complexity that comes with each can be an overwhelming topic for high school students. Students often have heard of the disorders or have some connection to a person with a disorder. In their effort to sort through the information feelings and emotions can surface. In this installment I will use the theme of creating a forum to help my students sift through the wide array of disorders and their varying characteristics.

The students will become both the presenters and audience in a poster session style forum. Each pair of students will research the genetic counseling profession and one disorder. Students will be given some starting points (links below) and required components (ex. symptoms, frequency in the population statistics, modes of transmission, prognosis, etc.) for their

research but will be allowed to expand from there. From their findings students will write up a detailed fictional case study of a family or individual that is being counseled on the disorder that they researched. The fictional account can include aspects of real cases that they find through their research. The students will then create a poster that outlines the case and essential information about the disorder and a brief presentation of the case. The poster session will be the culminating event for the project. The pair of students will take turns; one presents while the other visits their peers posters and learns about the other disorders and cases. Teachers and other staff members will also be invited to the session to give is a more robust feel and bring some formality to the process.

The project is aimed at getting students to see the wide variety of disorders and also to provide the human aspect through the fictional cases. Additionally students will need to have some guidance or inspiration as the visit each poster to stimulate discussion about the case and/or the disorder. Giving students free rein to just explore the session can lead to laziness and on the other hand giving them guiding questions can lead to students just checking off the boxes without having meaningful interaction at each poster. Having other adults in the session would improve this but ultimately I want my students to get there on their own.

Genes and disease: Genetic dictionary listing many disorders
http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=gnd.TOC&depth=2

Info on certain genetic diseases
www.noah-health.org/en/genetic/

www.kumc.edu/gec/support/

www.genome.gov/10001204

health.nih.gov/result.asp/281

Genetics counseling info
http://www.salary.com/careers/layouthtmls/crel_display_Cat10_Ser138_Par238.html

http://www.kidshealth.org/parent/pregnancy_newborn/medical_problems/genetic_counseling.html

gslc.genetics.utah.edu/units/disorders/whataregd/