*I haven't changed much in the classroom implementation strategy. Comments, ruminations, and general New thoughts are in italics.*

We in North Carolina are updating and realigning our standards, and as I study them I see that the Biology standards may allow for a better mesh with my PolarTREC expedition than I had previously thought.

Biology essential standard 2.1: Analyze the interdependence of living organisms within their environments.

Biology 2.1.1: Analyze the flow of energy and the cycling of matter (water, carbon, nitrogen and oxygen) through ecosystems relating the significance of each to maintaining the health and sustainability of the ecosystem. The real details here are in the need to teach bio-chemistry along with ecosystems ecology…this is perfect for what I'll be working on this summer at Toolik. I like that the word "sustainability" is in there, as well. I think sustainability is a key concept that applies to so many topics: food production, energy production, population, even our own little Early College program, originally funded by grants, now long gone.

In my Needs Assessment, I highlighted information on climate change as a specific topic I'd like to address better. Our students have opinions about climate change formed from listening to their parents or the media, and I often find it as difficult to discuss climate change as it is to discuss evolution. I think this framework of Arctic tundra ecology will be an engaging and certainly authentic platform for learning about climate change. Before students can really begin to understand real science of climate, they need so many concepts under their hats. They need to understand:

The structure of the atmosphere, in order to understand how the sun warms our Earth, and in order to understand how climate scientists can attribute warming to non sun activity. This concept they learn in Earth Science prior to Biology: both 1.1.4: explain how the incoming sun's energy makes life possible on Earth, and in section 2.5.1: summarize the structure and composition of our atmosphere.

Basic chemistry: states of matter, properties of elements, bonding and chemical equations. This they learn in Biology: 4.1.: understand how biological molecules are essential to the survival of living organisms. They get this in middle school to a certain extent, but mostly as facts to memorize for an end -of-grade test, with little or no real understanding.

How carbon, nitrogen, oxygen, and water cycle in the environment. They get the water cycle really well, although most have forgotten evapotranspiration, or in biology fail to see the connection with plant respiration. I have been as guilty of this as any, not connecting the relationship of cellular respiration to the cycles of these important elements and molecules.

Techniques scientists use to gather information; sometimes I think the students believe that scientists just make stuff up; they get the idea of an educated guess, and their understanding stops there. Our students need to understand how science is learned, how experiments and research is carried out. I only learn by doing, and I can't expect them to learn in any other way. *After being at Toolik, and following so many expeditions the past couple of years, I'm really struck by the creativity of science…the implementation of whatever materials are on hand to make something or make something work better, the creativeness of coming up with testable questions, and possible hypotheses.*

So, the question is, what can I teach about climate change and working science that can make an impact on their understanding of the topic, and help them gain an appreciation for the process of science. How can I teach it using primarily inquiry based methods?

At Toolik, Dr. Weintraub's research team is looking at the seasonal changes in nutrient availability in the tundra. So what does this have to do with climate change? The research team is teasing out the mechanisms of Nitrogen availability to plants during the growing season. N is available early on in the growing season, and then becomes much less available. Since this nutrient cycling is seasonal, the team is looking at how changing seasons will affect nutrient cycling. They are looking specifically at changes caused by earlier snowmelt, and by warming temperatures. Some of the things they are looking at include root nutrient uptake, plant green up through the growing season, ecosystem respiration, and microbial biomass. I've been thinking about how to bring this research to my students.

This coming year, my biology class will take place in the spring. I plan to hook them in to Project Budburst (http://neoninc.org/budburst/) in order to begin taking observations of plant growth relative to seasonal changes, and how these changes are being affected by local changes in climate. This gives the students a specific phenomenon to look at and take measurements of. We can establish plots this spring, and those areas can be followed up by future classes in the years to come. This helps the students to understand what is meant by seasonal changes, and helps them to learn more about the ecology of our Southern Appalachian Mountains. *I had my Earth Science students contributing to Project Budburst this fall as we watched senescence in a grove of red maples. I'm still planning on looking at budding, leaf on, and other phonological phenomena this spring with my Biology classes.*

Speaking of the Southern Apps, we study biomes. My experience in the tundra will make it especially interesting and helpful in comparing firsthand knowledge of the Arctic tundra to our mountains. *I incorporated this a little in my Earth Science course this fall, mainly sharing websites and my firsthand info about the tundra. I would like to have the students more actively involved in the biomes comparison as some sort of research project.* Students can learn about temperature and precipitation data from the tundra, as well as compare it to that of our mountains here. A follow up activity would have them learning about several indicator species of both areas, and summarize several food webs they may choose to explore. *This should work well this spring; as we study not only indicator species but invasive species. This will go along with information learned at Toolik about the changing plant life in the tundra, progressing from the tussock tundra into a more shrubby tundra.*  This brings the students to the concept of cycling, and we can move on into the N and C cycles from this point. *Boy, the most important part of our studies at Toolik, and I am still working on ways to successfully implement this into my curriculum in a meaningful, hands on way.*

We have done simple tests on soil in the past, measuring pH, N, P, and K. We can expand on this with a more in-depth study of the Nitrogen and Carbon cycles. We can test N in our garden plots, and in the adjacent woods. We can also look at soil N levels from data from Dr. Weintraub's arctic tundra studies. This helps us travel further into the biome studies. *Yes, we can do this, especially as our garden season swings into gear.* As a way to bring the life kingdoms alive, we can do a study on soil microbes, as well as plant functions. I think we can design an experiment to test ideas about nutrient uptake by roots. I'm not sure what this will be, yet. I believe this might be a good topic for the I-Mold animation to address. This will come much easier, also, after spending the summer learning the various nuances of this research.

Another component of my classroom implementation will involve decomposition. Students have looked at decomposition from the standpoint of how long it takes various items of garbage to decompose. We can take up samples of leaf litter and do simple decomposition observations of the samples as far as changing mass or chemical makeup changes. *I hope to write up a rough lesson plan about decomposition.*  I would also like to bring in concepts of productivity, as well as respiration of decomposing matter. I'm not quite sure how to measure this without an IrGA, but I think I will come up with ideas from working with the scientists this summer. *Still not quite sure on this one, I might enlist my colleagues at Coweeta Hydrologic lab for some local help on this. Possibly have a tech or scientist come out with the IRGA and demonstrate what it measures, how and why.* One particular aspect of focus will be on the I-Mold project; perhaps we can take virtual measurements of respiration.

For this coming summer, I've proposed an online class for my high school students. This class will focus on my field experience this summer, but also allow me to try several different teaching ideas with a small group of extremely motivated students. The course has been approved by my administration and 5 students have signed up so far. I have pasted the outline of the course below:

Follow an Arctic PolarTREC Expedition!

1 credit course ~ six weeks

24 May - 6 July

I. Follow Ms. Steiner's expedition and your choice of at least one other

 Keep structured notes responding to the journals

 Note thoughts and questions about the information posted

 Post at least 3 questions in the Ask The Team forum section of Ms. Steiner's Expedition

 Read 2 related short texts and write one page summary/response

2. Research Paper

 Write a short 2-3 page research paper about topic related to the Arctic

 Topics could be related to information in any of six broad categories: atmosphere, oceans, land, animals, plants, or science technology used in Arctic research

 Your journal, or part of it, may be chosen for posting on Ms. Steiner's expedition page!

3. Design a demonstration or experiment that could be carried out in the Arctic

 What question can you come up with that could be answered while Ms. Steiner is in the Arctic tundra? Can you think of a demonstration that could be done via Skype that would get across a principle related to the ongoing research during Ms. Steiner's expedition? Write up the experiment or demonstration including:

A hypothesis, Materials needed, and a Procedure to carry out the demonstration or experiment.

 I would like to be able to do a student designed demo or experiment while in the Arctic. For instance, students at home could monitor decomposition of a leaf clump over the time period, and I could monitor the decomposition of a similar mass leaf clump through the summer. Perhaps the students and I could have a simultaneous solar oven cook-off: me in the Arctic with 24 hours of sun and the students here in the mountains. Other ideas include sun shadow monitoring, growing of some bean seeds, or something along that line. We also have a weather station set up, and we can do direct comparisons of temperature and precipitation over the summer time period. The idea will be to test out these ideas to better incorporate them during the regular school year.

*I had only two students complete the course; most of our students do not have good Internet access at home, so I think that was a factor. Plus, the summertime mentality does set in, especially for kids. Several students followed the expedition for varying lengths of time, but only two students completed all the requirements and got the credit. For an experiment, I tried to conduct infiltration rate activities; one in the tundra compared to theirs in the mountains. I had trouble explaining to the students how to do it, but I have video of my own trial at Toolik. I (finally) have these students again for Biology this spring semester, so it will be fun to work that in to class time for all to do.*