2005

Worldview, Science and the Understanding of Nature

William W. Cobern
Western Michigan University, bill.cobern@wmich.edu

Worldview, Science and the Understanding of Nature
(Scientific Literacy and Cultural Studies Project #169)

Dr. William W. Cobern, Director
The Mallinson Institute for Science Education
Western Michigan University
3225 Wood Hall
Kalamazoo, MI 49008-5444
Voice: +269.387.5407 FAX: +269.387.4998
Email: bill.cobern@wmich.edu
Research Web http://www.wmich.edu/slcsp/index.htm

I am drawn to Nature because I see in Nature the handwork of God and I wonder what are our responsibilities as stewards of Nature? Being of a scientific bent, I wonder how Nature works? I wonder how Nature came to be? In other words, my thoughts– my everyday thoughts– about Nature are rooted in deep, fundamental beliefs that I hold about my life and the world in which I live, that is, my worldview. Nature of course is the traditional domain in which the "natural" sciences operate, but how we understand science and Nature is rooted in our worldview. This essay is about using worldview theory as a framework for investigating people's understanding and valuation of both science and Nature. Throughout I will draw upon the everyday comments made by younger and older students, teachers, and scientists about Nature and science. My purpose is to draw attention to the multiplicity of views amongst even those who share a common society. That multiplicity is the backdrop for whatever it is that one wishes to teach about science and Nature.

A Personal Narrative[1]

My professional interest is science education for the general public– "Science for All" is the American expression– others, particularly the British refer to the "Public Understanding of Science." The notion is that a democratic citizenry should be scientifically literate. Within this context of public scientific literacy, I am particularly interested in the notion of a "scientific worldview" and how such a perspective interacts with other important ideas that people have, including ideas about Nature. Nature, or the natural world, is after all the domain in which the "natural" sciences operate, and the natural sciences can be distinguished from other domains such as religion. Recall the famous phrase that Galileo borrowed from Cardinal Baronio: "The Bible tells how to go to heaven, not how the heaven goes." Nevertheless, science and Nature are aspects of more than one system of meaning that people construct for making sense of their worlds: "An aspect" of meaning because science is not the entire ball game except for a few people who chose to elevate science to the level of metaphysics; "different systems" because even among scientists there are differences as to how science is used in the construction of meaning and how Nature is understood.[2] For me, awareness of this assertion came through personal experiences that I will briefly relate.

[1] Some of the material for this section was adapted from Cobern (1997).
[2] It should of course be understood that some people are completely disinterested in science and some people are hardly touched by science. However in the Western world, if not beyond, even those completely disinterested in science cannot help but be influenced by science.

I personally cannot think of a time when I was not interested in science. Typical of many students I do not remember much science being taught in my elementary grade classrooms. What I remember is the power and the wonder of the Pacific Ocean to the west of our home and the majesty of the Sierra Nevada Mountains to the east. I recall the fascination of flight whether the flight of birds or of airplanes. I remember being glued to the television set through the great events of the Apollo missions. From junior high school on I do remember my science classes - not because my science teachers were exceptional. They were not. I do not recall ever having a science teacher I would call an exceptional teacher whereas I clearly recall a high school English teacher who was a superb teacher. As research has shown there are students who seem almost naturally drawn to science; and it appears to matter little what happens in school science, these science enthusiasts continue inexorably along the scientific pathway (see Costa, 1993, 1995). School science is a *de facto* natural selection device for screening the majority of students out of science (West, 1996).

Some of my interest in science and Nature is as a result of my Christian faith. I am moved by the words of the Psalmist:

> [1]The heavens declare the glory of God; and the firmament sheweth his handywork. [2]Day unto day uttereth speech, and night unto night sheweth knowledge. [3]There is no speech nor language, where their voice is not heard. [4]Their line is gone out through all the earth, and their words to the end of the world. In them hath he set a tabernacle for the sun, [5]Which is as a bridegroom coming out of his chamber, and rejoiceth as a strong man to run a race. [6]His going forth is from the end of the heaven, and his circuit unto the ends of it: and there is nothing hid from the heat thereof. (Psalms 19, KJV)

I am quite unimpressed with the ideological atheism of some scientists, from George Gaylord Simpson (1960) to Dawkins (1986) who seem to think that Darwin rendered God superfluous. In a passage about Darwin and his work on the Galapagos Islands, David Hull once asked, “Could anyone believe in God and the Galapagos?” (Larson, 2001). Quite to the contrary, when I first studied evolution, my inner response was: “Oh, so that’s how God did it.” Indeed, David Lack, the very biologist who did the seminal evolutionary studies on what are known as “Darwin 's finches” converted from agnosticism to orthodox Christianity the year after publishing his landmark research.

None of this is to say that I have never had mixed feelings about science. I was a university student at a time of national crisis. It was the late sixties – the height of the Viet Nam War. Many of my friends had a very negative evaluation of science because of what they perceived as an unholy alliance between the community of science and a military-industrial complex that developed and produced weapons. The rhetoric of values neutrality was not tenable when the science community having taken credit for such things as the “Green Revolution” denied any responsibility for “Agent Orange” and the like. We know historically that they were not the first to reject the values-neutrality rhetoric of science. For example, Japanese intellectuals prior to World War II saw modern science as one of the chief threats to Japanese culture (Buruma, 2004). However, if I think only of my science studies at the university, I have to say that the university study of science was a heady experience. Take for example the long laborious and grueling hours spent in a *Drosophila* laboratory working out genetic arrangements and chromosomal structures for fruit flies. To my friends in other disciplines this was certainly the best example of a silly and boring use of one’s time. I can only describe the experience as *heady* because we were actually working out the physical mechanisms that made the particular fruit fly look they way it did. And then to actually photograph the chromosomes, what a thrilling

experience! A year later we took the next step and actually extracted DNA. Again, what a thrilling experience not only to know Nature at such a fundamental level, but to touch Nature at such a fundamental level. At the time of these experiences we also met some of the great stars of scientific research. I had the honor of studying biology with Paul Saltman and physical chemistry with Stanley Miller. We had guest lectures by Günther Stent and Max Delbrück. Who needs Hollywood when you have just been to a lecture by Linus Pauling? Perhaps this is hyperbole but these experiences lend themselves to positive exaggeration — at least for the science enthusiast.

Indeed, the heroic stories of scientific investigations were almost as good as any film. One story that has long fascinated me is the story of identifying the DNA synthesis enzyme because it seemed the perfect example of Karl Popper's conjectures and refutations. In 1957 Arthur Kornberg isolated a polymerase enzyme from *Escherichia coli* bacteria that would synthesize DNA *in vitro* – conjectured and confirmed. Well, confirmed yes; but was the conjecture true? John Cairns was a doubter and he set about searching countless quantities of *E. coli* bacteria attempting to find a mutant strain of *E. coli* lacking Kornberg's enzyme but still capable of reproducing itself – that is, replicating its own DNA. His attempt at refutation was successful and Kornberg's enzyme though originally confirmed as a DNA synthesis enzyme turned out to have a different function in the natural setting of a cell. Perhaps this a minor story in the history of biology but the broader history of molecular genetics can take on epic proportions. One of the best accounts of this history is suggestively titled, *The Eighth Day of Creation* (Judson, 1979). The less than subtle allusion is of course to the Bible's account of the seven days of creation.

The stories of scientific success were important beyond their explicit purpose of teaching scientific concepts. The stories bolstered student confidence in science. For example, when we did those DNA extraction experiments, the truth is that we students only understood portions of what was being done. If any of us had been vigorously pressed to answer how we knew that sticky stuff on the glass rod was really DNA, we would have struggled to answer. We knew in part but much else we accepted on the basis of scientific authority vested in the professor and laboratory instructor. *Why wouldn't we? We had heard the stories*. It never occurred to us that we had *faith* in science and scientists. Several years later the basis for that faith was dramatically reaffirmed for me. My wife and I were expecting our first child. As it happened, Alex was born several weeks pre mature and suffered from fetal respiratory distress syndrome. Upon birth, his lungs had not opened fully and the fetal duct that allows blood to bypass the lungs of an unborn baby had failed to close at birth. We were living in San Diego at the time and Alex was immediately transferred from the hospital of his birth to the University of California-San Diego teaching hospital. This hospital had a neonatal research ward where one of the specialty interests by God's grace happened to be fetal respiratory distress syndrome. Perilous days followed but Alex pulled through with no lasting ill effects. Had he been born only a few years earlier and with this syndrome, he would not have lived through his first twenty-four hours. Why wouldn't I acknowledge the authority of science?

The excitement I felt as a student of science and the power I witnessed with my son's full recovery are grounded in the powerful ideas and methods that science has uniquely contributed to our culture in the 20th century. Cultural historian O. B. Hardison remarked that "no examination of modern culture can exclude the influence of science and technology, and one that underestimated their influence would be irresponsible" (1989, p. xi). There is cultural capital in science that properly belongs to everyone—but exactly what that capital is, and just how science and Nature are to be understood varies amongst people, even amongst people who are scientists.

These different perspectives on science and Nature are intriguing. What I have learned about these differences began in 1979 when I took a university position in Nigeria.

Science, Nature & Worldview

I had the privilege of teaching at the University of Sokoto,[3] Nigeria, from 1979 to 1983. Shortly after I arrived at Sokoto, some Nigerian colleagues told me a story that well illustrated the cultural differences between Americans and Nigerians. The story presented a moral dilemma and it goes like this:

> Imagine that you are out on a lake in a boat with a spouse, a parent, and young son or daughter. Of the four in the boat you are the only one who can swim and the boat has no life preservers. Suddenly the weather turns bad. The boat flounders and all are cast into the water. You quickly realize that with the distance to shore you have hope of only saving one of your passengers, your spouse, your parent, or your child. Which one will you save?

It is a difficult decision, of course, but most Nigerians quickly came to the same answer. They would save the parent. Americans also find this to be a difficult decision but most come quickly to the same answer—but not the same answer that the Nigerians come to. Americans generally agree that it is the child who should be saved. What different ways we have of seeing the world!

Cultural differences about how one understands the world, particularly the natural world, and hence the influence on science captured my attention. To formally pursue investigations, I adopted a theoretical framework from cultural anthropology, worldview. Worldview refers to the culturally-dependent, generally subconscious, fundamental organization of the mind. This conceptual organization manifests itself as a set of presuppositions that predispose one to feel, think, and act in predictable patterns. Kearney (1984, p. 1) referred to worldview as,

> culturally organized macrothought: those dynamically inter-related basic assumptions of a people that determine much of their behavior and decision making, as well as organizing much of their body of symbolic creations... and ethnophilosophy in general.

To be rational simply means to think and act with reason, to have an explanation or justification for thought and action. Such explanations and justifications ultimately rest upon one's worldview. Thus, worldview is about epistemological levels antecedent to specific views that one holds about physical phenomena, whether one calls those views commonsense theories, alternative frameworks, misconceptions, or valid science.

The Kearney (1984) model of worldview is composite structure of inter-related, universal categories: Self, NonSelf[4], Classification, Relationship, Causality, Time and Space (Kearney, 1984). Each category is composed of logically related presuppositions. In principle groups of people and even individuals can be identified by worldview variations that result from the content variation of categories. This composite nature of the model focuses the researcher's attention on the complexity of worldview, and yet the categories themselves provide access to that complexity. And while the composite nature of the model makes it less likely that the researcher will oversimplify the notion of worldview, one can still speak of worldview unity

[3] The University of Sokoto has since be renamed the Usman Dan Fodio University.
[4] Kearney (1984) uses the term "Other." I prefer "NonSelf" because I think NonSelf more readily conveys the meaning intended.

based on salient presuppositions within the seven universal categories. Kearney (1984) refers to this worldview model as *logico-structuralism*.

Logico-structuralism, as its name implies, is a structuralist approach to worldview. *Structuralism* began in France in the late 1950s, inspired by anthropologist Claude Levy-Strauss who maintained that there were universal structures that appear in all cultures. Levy-Strauss (1963) argued that culture, including artifacts, language and speech, are indicative of underlying structures of thought that characterize a society or group. *Structural Analysis* is the method of structuralism for examining the typically subconscious infrastructure of cultural phenomena, which regards elements of infrastructure as relational and not as independent entities. Hence, the subconscious infrastructure of cultural phenomena acts systemically. The goal of structuralism is to elucidate (after the fashion of the physical sciences) general laws accounting for underlying organizing patterns of phenomena. By the 1980s, however, structuralism was being replaced by poststructuralist[5] or postmodernist ideas, which began:

> to challenge the possibility of such simplistic, unidirectional causative analyses, while continuing to argue that reality is in some significant sense hidden from direct observation and common sense. Poststructuralism removes all foundational categories by re-examining them as the causative products of some other factors. There are no available a priori on which to ground human reason, no Archimedean point of reference. (Grassie, 1997, p. 86)

Postmodernist critiques have been persuasive but also quite controversial. However, it is not so controversial to conclude that the modernist project in anthropology to elucidate general laws accounting for underlying organizing patterns of phenomena was ill fated from the very start. The improbability that physics-type laws could be found that under gird culture does not mean that there are no commonalities amongst people who are by culture quite diverse. The argument of logico-structuralism is that all people everywhere have some sense of Self, sense of what is other than Self (i.e., the NonSelf), Relationship with the NonSelf, how the NonSelf is Classified, and the nature of Causality, Time and Space. Therefore, as one seeks to understand different cultures and cultural differences, the composite nature of logico-structuralism focuses attention on the complexity of worldview, the categories forming the composite provide access to that complexity.

Given that my field is science, I am interested in Nature, the domain in which the *natural* sciences operate. Following Robert Redfield's (1952) tripartite division of the NonSelf into: Humanity (society), Nature, and God (the transcendent), it is easy to see how concepts of Nature fit within the logico-structural model and how various other presuppositions within worldview categories interact with the concept of Nature. Fundamentally, the relationship between the Self and NonSelf can be one of harmony, subordinance, or dominance. In actuality there is likely to be mixing. For example, the Self-NonSelf relationship with regard to the individual and society may be one of harmony, while the individual-Nature relationship one of dominance (Kearney, 1984, pp.72-78). Historically, a relationship of dominance derived from the *Genesis* account of creation was crucial to the development of experimental science (Hooykaas, 1972; Glover, 1984). In the words of one Japanese observer:

> In the Western idea, man was not an ordinary part of nature. He was a specially privileged creature, and nature was subordinate to him...he was the master of the

[5] Consistent with Grassie (1997), I take poststructuralism and postmodernism mean essentially the same thing.

> natural world, which was at his disposal to analyze, examine, and make use of...since the natural world and the whole universe were manifestations of God's creation, the study of it was not only a useful but also a highly esteemed endeavor...such an outlook provided some of the important religious motivation which fostered the development of modern science in the Western world. (Watanabe, 1974, p.280)

This dominance theme continues to be important in science today, though not without problems (see White, 1967; Young, 1974). In stark contrast, for traditional Chinese and Japanese the relationship between Self and Nature is one of affinity and sympathy. The difference between East and West is nicely illustrated by a story told to Watanabe by an American missionary to China:

> Three men went to see Niagara Falls. One was an Indian from India, one was a Chinese, and one an American. On seeing the falls, the Indian, as a matter of course, thought of his god, manifested in this grandeur of nature. The Chinese simply wished to have a little hut beside the falls, where he might invite a friend or two, serve tea, and enjoy conversation. The American, however, on viewing the falls, immediately asked himself what could be done to make the most of such an enormous amount of energy. (p.279)

Although this story is about stereotypes, there is the essence of truth. Americans frequently view Nature as an object for "mastery." In other cultures Nature is more likely to be valued for its beauty, if not actually held in reverence. These differences in worldview have consequences. Watanabe noted that despite the frequency of earthquakes in Japan, it was only after contact with Westerners that the Japanese began the scientific study of earthquakes. According to Watanabe, "this can be explained largely by [the Japanese] attitude of coexisting with nature" (p.281). Anecdotes such as these are easy to find in the literature

American Students and Their Teachers Speak about Nature and Science

In recent studies, I have used logico-structural theory as the basis for investigating conceptualizations of Nature held by scientists, high school science teachers and their students (Cobern, 1993, 1997 & 2000; Cobern et al, 1999; Cobern & Loving, 2000).[6] Data is collected via interviews and it is critical to understand that at no time during an interview does the interviewer introduce the concept of science. The interviews are about Nature and if science is to be discussed it is the interviewee who must initiate the discussion. Hence, these interviews provide interesting insights on the various ways people make sense of science and Nature.

In this section, I introduce the reader to several participants from my studies. The thoughts conveyed by these participants illustrate the variety of thought people have about science and Nature, and the association of one to the other. I shall begin with Mr. Hess[7] who is a physics teacher. In many ways, he is the stereotypical scientist. Without any prompting about science, Mr. Hess immediately begins to discuss Nature in terms of reductionist science. He is the "Optimistic Reductionist."

Mr. Hess:

[6] For a thorough discussion of the qualitative methods used in these studies, see Cobern (2000).
[7] All names are pseudonyms.

> I think that everything has patterns. We haven't necessarily discovered those patterns, yet I feel that with enough scientific knowledge all things are understandable. I think that the more we understand about matter itself, and the more we know about how to make things, the more predictable Nature will be. Scientific or reductionistic thinking is very powerful. I feel that once we know enough about the minutia of the world, breaking it down by using the scientific method, scientists tearing it apart and analyzing the parts of Nature and seeing how they interact, that we will be able to predict just about anything about Nature. Eventually, all Nature will be explainable.

Perhaps it is of little surprise that some high school students have similar thoughts. One them is Howard.

> **Howard:**
>
> I think that Nature is understandable. We don't understand all that there is to Nature at this moment but we will understand more and more as time goes on. Most things about Nature are somewhat orderly and/or have a pattern to them. Because of this the study of science allows us to explain what is going on in Nature. The orderliness also lets us predict many things that are going to happen in Nature, like the weather, for example. Sometimes Nature seems chaotic but that is mostly because our knowledge is incomplete and therefore our understanding is limited. I think that most things in Nature can be explained by science. Matter, both living and non-living, and what it does follows basic laws. Things like the law of conservation of mass, reproductive cycles of plants and animals, convection currents and ecosystems can be understood if the laws of science are studied.

To no one’s surprise, it is easy to find a college professor of science who holds similar views.

> **Prof. Flock:**
>
> My definition of Nature is more biological. I look at Nature as interactions between living and non-living. As my area is ecology so I sort of look at Nature from an ecological point of view. I always like to look at the interactions. Nature is something you can observe and measure, so it's very real. You can see the order in it. You can measure it. You can predict it. It is knowable. I don't like the word “mysterious.” Mysterious, divine… it's like there's no answer. But I think there are answers to things that happen, so I don't think Nature is mysterious. I don't think you can answer everything that goes on in Nature. I don't think it's necessarily predictable but I don't think it's mysterious. And, I do think about Nature quite a bit.

Nature, for Howard, Mr. Hess and Professor Flock, is best understood in materialistic and reductionist scientific terms. About science and Nature, they are quite triumphant. In the same school, however, where Howard attends and Mr. Hess teaches, there are also oppositional students such as Art whose view begins with the identification of humans with Nature.

> **Art:**
>
> I believe that man does not stand separate from Nature but is part of it. Nature is a source of knowledge... At the present time our knowledge of the natural world is limited. As we gain in understanding of the diversity and power of Nature, we will understand the perfect balance of everything in Nature. We will also begin to understand our place within Nature. It is more important to have a spiritual

> understanding of Nature than just scientific knowledge. That understanding can't be gained from school. You have to spend time in Nature and learn to feel it. Then you will understand it. Animals are very important to me; I can feel things through animals. Scientists are people that understand the need to preserve and protect. Unfortunately, scientists and scientific knowledge are also increasing our tendency to pollute, destroy and clutter up the earth and space. Scientists are trying to destroy Nature and study it at the same time.

When I interviewed Art, I was reminded of something I had read about mushroom collectors. Mushroomers are hobbyists who:

> Emphasize that mushrooming puts them in touch with Nature and provides a needed contrast to the stresses of the working world. Many see a sharp division between man and Nature, and their sympathies lie with the latter. They want to appreciate Nature. As one explained, “Life on earth could exist very nicely without people, but it couldn't exist without fungi. Human beings are the biggest threat to Nature…. Man should try to have as little impact on the environment as possible.” (Fine, 1989, p. 611)

Fine (1989) goes on to explain that sometimes mushroomers are reluctant to show their collections to professional mycologists because the scientists can have a very different perspective on Nature.

> Amateurs may look askance at some professionals' lack of interest in mushrooms as aesthetic objects. Rather than identifying them from the macroscopic characteristics, professionals destroy mushrooms in the course of identification. For example, one amateur told that one professional tears mushrooms apart as he is identifying them, making them unrecognizable. “I'm told that on one occasion he said, 'I don't know what that is anymore,' and threw it away. That way he has no problem.” (Fine, 1989, p. 611)

But clearly not all scientists are like this scientist that G. A. Fine tells us about. Nor are Mr. Hess and Howard stereotypically scientific, given that other members of the scientific community express quite different views about science and Nature. Consider another scientist from my interviews responding to questions about the nature of Nature.

> **Prof. Blisstic:**
>
> My first response about Nature, well, to be really honest, the deep down feeling would be delightful, pleasant, beautiful, and attractive. Like I said, the first image that comes into my mind are mountains, lakes, wilderness, those kinds of things so that would be, to be perfectly honest, not at the intellectual level, but that is what comes up first here. I also think of things like insects…. because that's what I'm interested in and… there's a lot of aspects of things. Even like insects, most people think that “a bug is a bug,” … if you look at them under a microscope or you watch them for hours like I have, you find out that there's some really beautiful aspects about… insects, their behavior and all that kind of stuff.

Consider also one of Mr. Hess’ colleague teachers. Mr. David could be dubbed the “Scientific Buddhist.”

Mr. David:

> Nature is orderly and chaotic, predictable and unpredictable. These pairs are sort of needed in order to define each other. Things wouldn't be predictable if you didn't know what unpredictable was. Things wouldn't be orderly if you didn't know what chaotic was. It is sort of a Ying-yang relationship between the two. I would call this just the dualistic Nature of reality. Living, mysterious, and exciting – these are terms I most closely associate with in the natural world and how it appears. It's alive. It's mysterious and we don't understand it, and it's exciting... there is a lot that we don't know about it

Mr. David is almost religious in his views about Nature, and science is interpreted within that framework. Not many students, if any, at Mr. David's school shared his Buddhist inclinations but many did share a religious orientation toward Nature. Patricia and Ann, for example, bring a Christian interpretation to Nature and science.

Patricia:

> God created the natural world. Nature has many characteristics: it's powerful, diverse, changeable, and beautiful… physically and emotionally. The Bible says God created the heavens and Earth, so I think that explains to me what Nature is. The wonderment of the world increases knowledge through science, but is limited, due to Nature's complexity. Both views, scientific and religious, try to explain hard questions such as the origins of life. Science and religion have distinct roles in our life's teachings. Science teaches us how to conserve our resources, and how to possibly restore them, while religion teaches us the caring attitudes required to be productive members of the natural world…. People must learn to take the time to enjoy the beauty of Nature, both religiously and scientifically.

Ann:

> To me, Nature is beautiful and pure because it is God's creation. Nature provides both aesthetic and emotional pleasure and I need it for self-renewal. I like to go where you can't see any influence by man. When I'm out in Nature I feel calm and peaceful. It is a spiritual feeling and it helps me understand myself. The pleasure I get from Nature is enhanced by the mysteries I see in it.

On the other hand, some scientists may reject such religious views.

Prof. Flock:

> I don't really deal with the spiritual. Could Nature be spiritual? It could be but I can't deal with things I can't measure and observe so I always throw those ideas out right away, simply because I can't deal with them. I mean, it could be or couldn't be; it's anybody's guess. You know, so if I can't measure it, if I can't observe it, then I can't deal with it. I don't see a divine work in Nature. I don't see evidence of it or evidence not of it. I can't deal with it. I can't say there is a purpose, I can't say that it is or is not the work of God in Nature. So, if it doesn't have really a scientific kind of merit, then I am just not interested.

Ann tells us that she finds pleasure in the mysteries of Nature and some scientists agree.

Prof. Blisstic:

> Nature can also be mysterious. I think that goes back to not being able to understand it, as well as... not knowing. I like a big mystery so mystery is not a bad for me. I think of it as an intellectual challenge... mysteriousness because if you don't understand something, and you want to go look for the answer, find out more about it and try to understand it better.

One of the science teachers at Ann's school also shares this view. He is Mr. Bradford, the "Lover of Scientific Mysteries."

Mr. Bradford:

> Nature is more powerful than the minds of people who are trying to conquer it. Nature is really not knowable. No one will ever know everything there is to know about Nature and that is part of its appeal; because [Nature] is so mysterious. Not only will nobody ever know everything there is to know about Nature, hopefully no one ever will. To me, the mysterious Nature of Nature is one of its better qualities. Things that are completely discovered are no longer interesting.

Consider the contrast between the two science teachers, Mr. Bradford above and Ms Jackson below.

Ms Jackson:

> I think that Nature is predictable. I think that it is logical. I think that it is explainable. As scientists, we come up with laws of Nature or theories of Nature to be able to predict behaviors. And we can predict those things because they are orderly, there are certain patterns that we can find, and yet at times they can be very complex. But I think Nature, you can understand it, you can know it, and you can predict it. I feel like we know an awful lot. I feel like, that, even though we don't have all the answers, we have so much, ways of finding out answers. I feel that we know an awful lot. I think we would definitely be up towards the 80 percentile of knowledge.

One says that Nature is more powerful than our scientific minds and the other claims that the complete explanation of Nature is at hand! On the other hand, there is one thing that all four of these science teachers share and every scientist I have interviewed. It is an interest in, and concern for, Nature, which is something not shared by all of their students.

Holly:

> The natural world is just there, you know, fish, bugs, dirt, animals, and plants. There are aspects of Nature that have purpose because it was probably created by God, but I am not really religious so I can't explain it. Nature is very big and complex, like the ocean, which makes it somewhat confusing to know about. The natural world is exploited; like our resources that we use for medicines, paper and breathing. People need to realize that our resources need to be protected because they are necessities for life. They can be recycled. I do not recycle because it is probably not in danger now or during my lifetime, so what's the point?

Holly has neither religious nor scientific interests in Nature; and although she is aware of environmental issues, she is blithely unconcerned. So here we have four science teachers and several of their students, all from the same American high school, and several scientists. They

are all Euro-Americans; all middle class citizens. In many ways alike and yet so different in their thinking about science and Nature. It thrusts upon us the interesting question about what it could possibly mean to have a "scientific worldview"?

The Problem of Scientism

The common threat to both Nature and science– as well as to the arts and literature and religion – is scientism – the cultural hegemony of science. The problem is not that science dominates at what it does best: the production of highly efficacious naturalistic understanding of natural phenomena. The problem is that too often science is used to dominate the public square as if all other discourses were of lesser value. This is a hierarchic view of knowledge with science placed at the epistemological pinnacle (see figure 1).

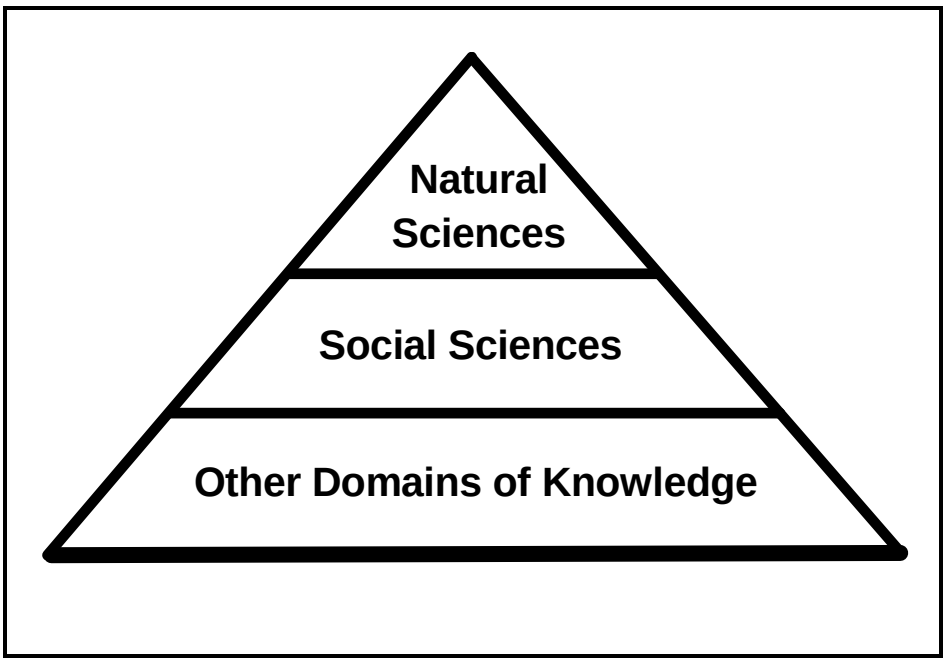

Figure 1. Epistemological Pyramid

For example, the National Academy of Science in America out of fear over religious incursions in school science issued this statement:

> In a nation whose people depend on scientific progress for their health, economic gains, and national security, it is of utmost importance that our students understand science as a system of study, so that by building on past achievements they can maintain the pace of scientific progress and ensure the continued emergence of results that can benefit mankind (NAS, 1984, p. 6).

Similarly, the International Council of Scientific Unions (ICSU) endorsed a perspective in the "Proposed ICSU Programme on Capacity Building in Science" (ICSU, 1996) that equates "the global gap of well-being" with "the global imbalance of science and technology development." The ICSU intends to:

> Demonstrate to the world that having the capacity to understand and use science is economically, socially and culturally profitable. Indeed, the very habitability of the planet will depend on global popular consensus. As such, the spread of scientific culture, of scientific ways of thinking, and of knowledge is tied to the fate of humanity. (p. 1)

About these statements we can say, of course, few people question the productive role that science has played in the development of modern life including medicine and contributions to good health, nor the economic gains due to technical innovations grounded in science (though the relationship between science and technology is not nearly so straightforward as these statements from the science community suggest). These claims by NAS and ICSU, however, are vastly overstated and singularly one-sided. Good health, economic well-being and national security all depend on many things only one of which is science. Moreover, as important as science surely is it does not have an uncontested claim to be the most important of these many factors. Curiously, though the National Academy of Science and the ICSU appear eager to accept credit for good technological innovations there is no parallel acceptance of technological disasters. If the science community wants credit for developing high yield grains that ease food shortages, how can the same community refuse credit for DDT? Something is wrong with this portrayal of science (we might even say *betrayal* of science). Garrard and Wegierski (1991, p. 611) suggest an explanation:

> It can be argued that technology and scientific positivism constitute the dominant ideology of Western civilization today. Technology has indeed become, as Heidegger noted, the metaphysics of our age, a totalistic form of secular religion ultimately incompatible with the existence of rival, nontechnological assumptions, beliefs, or thought systems.

I repeat. The common threat to both Nature and science– as well as to the arts and literature and religion – is scientism – the cultural hegemony of science.

Science, Nature & Epistemological Pluralism

I reject, however, postmodernist assertions of scientific and epistemological relativism that constitute an extreme rejection of science. Not all thoughts are equal. Not all ways of thinking are parallel. But life is a complicated affair and the skillful navigation of life requires a diverse repertoire of thought and reason. And what is essential for a suburbanite American to understand about Nature will not be satisfactory for a Nisga'a fisherman living in the very different world of the Canadian wilderness. Thus, what I value is the best thinking for a given situation and the wisdom to change one's thinking when situations change. I advocate epistemological pluralism and the ability to wisely discriminate amongst competing claims. This last point is important because the issues of life typically cross epistemological categories. It is not always obvious in the public when a problem does or does not call for a scientific solution. Should the USA have authorized four billion dollars to build a Super Collider? The scientific answer is probably "yes" since the Collider would have helped make important advances in physics. But, America decided not to build the Super Collider because science was out bid by the competing discourse of economics. In other situations we may find other domains of knowledge acting in consort with science. Snively and Corsiglia (2001) give a number of examples of ecologists and biologists profiting from indigenous peoples' traditional knowledge of Nature in Canada. The Native American Forestry Program at Northern Arizona University (1997) provides another example where science and traditional knowledge of Nature work in consort.

In other situations, however, science rightly precipitates and influences cultural change. Consider the following situation. At a recent National Association for Research in Science Teaching session, a researcher read the script of dialogue between an Australian Aborigine and a health care worker indicating totally different perspectives regarding the value and use of high-protein foods. The food is valued as nutrition, especially for children, in the West and valued as gifts in adult relationships to the Aborigines. The result of the latter perspective is continued high infant mortality for children under two years of age despite health care workers' careful use of Socratic methods to dignify the alternate views while educating the Aborigines. From the perspective of traditional Aboriginal life, that of a hunter/gatherer culture, the elevated social and political status of the elders makes their health critical to the success of the tribe. From that perspective they were correct to reject the science-based position (Loving, personal communication). However, cultures cannot maintain a status quo in the face of environmental change and expect to survive. The fact that the researcher was involved with an education program for Aboriginal peoples indicates that the researcher knew this full well. Thus in this case the possible cultural changes precipitated by science education regarding young children's need for high protein food are likely to be in the groups' long term best interests.

The unfortunate fact of this last example is that the researcher represented the Aboriginal rationale for distributing the best food to important adults as equally *scientifically valid* as is a distribution based on confirmed nutritional value and nutritional need at various stages of human physical development. But if all explanations are mistakenly valorized as scientifically valid (and there is no attempt at understanding the best *scientific* explanations), we are reduced to relativism of the worst kind. Privileging "what knowledge is of most worth" in science class is *not* the same as denying the value of other forms of knowledge (Loving, 1997). What is at issue here is the learning of when scientific knowledge should be appropriated over other competing domains of knowledge because it is the best knowledge available for the particular situation.

Science has a rightful claim to exclusivity, however, this claim does not confer to science all privilege vis-à-vis other domains. Science is properly privileged only within its own domain for that is where its strength lies. When our various ways of understanding Nature are devalued it is not because of an exclusive nature of science. It is because someone is involved in the scientistic practice of extending scientific privilege from its proper domain in science and technology into other domains. The solution is to resist this scientistic practice by emphasizing throughout the concept of epistemological pluralism, bearing in mind that pluralism,

> is not relativism… Pluralism is the civil engagement of our differences and disagreements about what is most importantly true. Against the monism that denies the variety of truth, against the relativism that denies the importance of truth, and against the nihilism that denies the existence of truth, we intend to nurture a pluralism that revives and sustains the conversation about what really matters, which is the truth. (Editor, 2000, p. 11-12)

Bearing *also* in mind that truth about Nature is never under the sole proprietorship of any single domain of knowledge – not even science.

CONCLUSION

I have through my research sought to better understand the concepts that have scope and force in students' understandings of Nature:

- What do students believe about the world around them, especially the physical world of Nature?
- How do students perceive their relationship to Nature?
- What are the science concepts used in student conceptualizations of Nature and to what extent are they used?
- How are scientific ideas related to ideas from other disciplines in the thoughts that students have?

In other words, it is important to understand the fundamental, culturally based beliefs about the world that students bring to class, and how these beliefs are supported by culture; because, science education is successful only to the extent that science can find a niche in the cognitive *and* socio-cultural milieu of students. The need for this understanding becomes imperative when one considers the vast cultural diversity facing educational systems.

Diversity about Nature is evident in almost all of my interview work. What is clear from my interviews with students, teachers, and scientists is that people tend to discuss the natural world using *several* different perspectives, for example, aesthetic, conservationist, religious, and sometimes even scientific. Teachers of science and scientists invariably begin discussions about Nature with science. For students who do not have a strong affinity to science – and that seems to be the majority of students – discussions about Nature rarely begin with science and sometimes never even get to science. On several occasions when I have asked students why in their comments about Nature they never said anything about science I have been met with: "But you didn't ask us about science! You asked about Nature." They, in other words, see no connection between the two. What a blinkered worldview it is that a teacher or scientist would bring to the classroom that would leave their students – even some of their scientifically talented students – thinking that science and Nature have nothing to do with each other. Most students seem to know that Nature is about meaning, purpose, beauty and mystery. Since when has science ceased to take an interest in these same things?

Is there some connection here with the widely attested loss of interest in science? Perhaps so. We can easily imagine Art, Ann, and Patricia wanting to know what science has to do with the meaning, purpose, beauty, and mystery of Nature. For these students science must be reconnected with Nature. But isn't that the need we all have? Drawing on my own experiences, I certainly think that it is. I grew up thinking that science provided an important complimentary way to understand Nature along with other ways that were important to me. I came to this by personal experiences in Nature augmented by a commitment to the Christian goal of understanding God's creation. Others have had similar experiences. The great naturalist E. O. Wilson though no Christian spoke of the early experiences in Nature that formed him as a naturalist.

> A child comes to the edge of deep water with a mind prepared for wonder… Hands-on experience at the critical time, not systematic knowledge is what counts in the making of a naturalist.... Better to spend long stretches of time just searching and dreaming.... Configurations with the greatest emotional impact are shared first and persist longer. Those that give the greatest pleasure are sought on later occasions. This process is strongest in children, and to some extent it programs the trajectory of their lives. (Quoted in Pitcher, 2004, p. E2)

This attitude of the naturalist[8] is what I am getting at. Unfortunately, it seems that many people have lost an integrated sense of Nature that includes science. Remember my students asking what science has to do with Nature. How this could have happened? – perhaps a reaction to the highly vocal exclusionary claims of a few scientists such as Simpson and Dawkins? I am reminded of Vaclav Havel:

> Classical modern science described only the surface of things, a single dimension of reality. And the more *dogmatically science treated it as the only dimension*, as the very essence of reality, the more misleading it became. Today, for instance, we may know immeasurably more about the universe than our ancestors did, and yet it increasingly seems they knew something more essential about it than we do, something that escapes us. The same thing is true of Nature and of ourselves. The more thoroughly all our organs and their functions, their internal structure, and the biochemical reactions that take place within them are described, the more we seem to fail to grasp the spirit, purpose, and meaning of the system that they create together and that we experience as our unique "self." (see Hobson, 1995, p. 1; emphases added)

Perhaps Havel has indulged some hyperbole but I suspect not too much so. Too often science is taught as more about abstractions than about Nature. And, where it is clear that science is about Nature, too often science seeks to be the sole interpreter of Nature.[9] Whereas the future of both science and Nature rests not on scientism but on a worldview integration that includes aesthetics, morality and God– something that the young students of my interviews seem to know far better than many highly educated adults.

References

Buruma, I. (2004 February). The origins of occidentalism. *The Chronicle of Higher Education*, p. B10.

Cobern, W. W. (1993). College students' conceptualizations of nature: An interpretive world view analysis. *Journal of Research in Science Teaching, 30*(8), 935-951.

Cobern, W. W. (1997). Public understanding of science as seen by the scientific community: Do we need to re-conceptualize the challenge and to re-examine our own assumptions? In S. Sjøberg, & E. Kallerud (editors), *Science, Technology and Citizenship: The Public Understanding of Science and Technology in Science Education and Research Policy* (pp. 51-74). Oslo, Norway: Norwegian Institute for Studies in Research and Higher Education.

Cobern, W. W. (2000). *Everyday Thoughts about Nature: An Interpretive Study of 16 Ninth Graders' Conceptualizations of Nature*. Dordrecht, Netherlands: Kluwer Academic Publishers.

Cobern, W. W., Gibson, A. T., & Underwood, S. A. (1999). Conceptualizations of nature: An interpretive study of 16 ninth graders' everyday thinking. *Journal of Research in Science Teaching, 36*(5), 541-564.

[8] To be a naturalist does not require Wilson's commitment to philosophical naturalism.

[9] At times the defense of an exclusionary view of science as the interpreter of Nature has reached hysterical levels. A good display of this is Gross, Levitt & Lewis (1996).

Cobern, W. W., & Loving, C. C. (2000). *Enacted* scientific worldviews: A case study of four high school science teachers. *Electronic Journal of Science Education, 5*(1).

Costa, V. B. (1993). School science as a rite of passage. *Journal of Research in Science Teaching, 30*(7), 649-668.

Costa, V. B. (1995). When science is "another world": Relationships between worlds of family, friends, school, and science. *Science Education, 79*(3), 313-333.

Dawkins, R. (1986). *The blind watchmaker: why the evidence of evolution reveals a universe without design*. New York: W.W. Norton & Company.

Editor. (2000). Putting first things first. *First Things,* (101), 11-12.

Fine, G. A. (1989). A morel community. *The World & I, 4*(10), 611-623.

Garrard, G., & Wegierski, M. (1991). Oh Canada? An essay on Canadian history, politics, and culture. *The World & I, 6*(1), 589-613.

Glover, W. B. (1984). *Biblical Origins of Modern Secular Culture: an Essay in the Interpretation of Western History*. Macon, GA: Mercer University Press.

Grassie, W. (1997). Postmodernism: What one needs to know. *Zygon, 32*(1), 83-94.

Gross, P. R., Levitt, N., & Lewis, M. W. (1996). *The flight from science and reason*. New York: New York Academy of Sciences.

Hardison, O. B. Jr. (1989). *Disappearing Through the Skylight: Culture and Technology in the Twentieth Century*. New York, NY: Viking Penguin.

Hobson, A. (1995). Vaclav Havel on transcendence and science. Physics and Society, 23(4), 1-5.

Hooykaas, R. (1972). *Religion and the Rise of Modern Science*. Grand Rapids, Michigan: William B. Eerdmans Publishing.

International Council of Scientific Unions (ICSU). (1996). *Proposed ICSU Programme on Capacity Building in Science*. Batavia, IL: Author.

Judson, H. F. (1979). *The Eighth Day of Creation: The Makers of the Revolution in Biology*. New York: Simon and Schuster.

Kearney, M. (1984). *World View*. Novato, CA: Chandler & Sharp Publishers, Inc.

Larson, E. J. (2001) *God and the Galapagos?* [Web Page]. URL Metanexus: http://www.metanexus.net/archives/message_fs.asp?ARCHIVEID=4069

Levi-Strauss, C. (1963). *Structural Anthropology*. New York, NY: Basic Books.

Loving, C. C. (1997). From the summit of truth to the slippery slopes: Science education's journey through positivist-postmodernist territory. *American Educational Research Journal, 34*(3), 421-452.

National Academy of Sciences. (1984). *Science and Creationism: A View from the National Academy of Sciences*. Washington, DC: National Academy of Sciences.

Northern Arizona University. (1997). *Native American Forestry Program*. Flagstaff, AZ: School of Forestry, Northern Arizona University.

Pitcher, E. B. (2004 February). A naturalist spirit usually is fostered early in life. The Kalamazoo Gazette, p. E2.

Redfield, R. (1952). The primitive world view. *American Philosophical Society, Proceedings, 96*, 30-36.

Simpson, G. G. (1960). The world into which Darwin led us. *Science, 131*(3405), 966-974.

Snively, G., & Corsiglia, J. (2001). Discovering indigenous science: Implications for science education. *Science Education, 85*(1), 6-34.

Watanabe, M. (1974). The conception of nature in Japanese culture. *Science, 183*(4122), 279-282.

West, P. (1996). *Basic College Science Courses Filter out most Students*. Washington, DC: National Science Foundation.

White Jr., L. (1967). The historical roots of our ecological crisis. *Science, 155*(3767), 1203-1207.

Young, R. V. (1974). Christianity and ecology. *National Review, XXVI* (51), 1454-1458, 1477, 1479.