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

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William W. Cobern, Ph.D.
Assistant Professor of Science Education
Arizona State University West
Phoenix, Arizona

Abstract

In Kuhnian terms, science education has been a process of inducting students into the reigning paradigms of science. While it may never have been explicit, the goals of science education clearly have been to persuade students that science provides a fairly constant, highly justified, and sufficient understanding of physical phenomena. In 1984, Duschl noted that science education had not kept pace with developments in the history and philosophy of science. Positivism was dethroned years ago and it turns out that factors surrounding discovery are at least as important as the justification of knowledge. Indeed, the entire concept of justification has been drastically changed.

Capitalizing on these new developments, Duschl, Hamilton, & Grandy (1990) wrote a compelling argument for the need to have a joint research effort in science education involving the philosophy and history of science along with cognitive psychology. However, the issue of discovery compels the research community go one step further. If the science education community has been guilty of neglecting historical and philosophical issues in science, let it not now be guilty of ignoring sociological issues in science. A collaborative view ought also to include the sociological study of cultural milieu in which scientific ideas arise. In other words, an external sociological perspective on science.

A sociological perspective provides a different view of students. Many students do not deem induction into a scientific paradigm as a thing desirable. Thus, the presentation of a major scientific concept such as evolution is rather less like two evolutionary biologists debating the fine points of evolutionary theory, and rather more like Darwin presenting the *Origin of Species* to a public who historically had a very different view of origins. Studies in the sociology of knowledge have provided insight into the origins of Darwin's ideas and how those ideas came to be accepted in the scientific community of his day. Shouldn't that same perspective help science educators understand how science is received and understood by their students? The logic of discovery from a sociological point of view implies that conceptual change can also be viewed from a sociological perspective.

Science education has long been grounded in a philosophy of logical positivism which minimizes factors that surround discovery while emphasizing the justification of knowledge. In Kuhnian terms, science education has been a process of inducting students into the reigning paradigms of science. While it may never have been explicit, the goals of science education clearly have been to persuade students that science provides a fairly constant, highly justified, and sufficient understanding of physical phenomena. In 1984, Duschl noted that science education had not kept pace with developments in the history and philosophy of science. Positivism was dethroned years ago and it turns out that factors surrounding discovery are at least as important as the justification of knowledge. Indeed, the entire concept of justification has been drastically changed, so much so that an article was recently published on the "demise of justification" (Eby, 1991, p. 531).

Capitalizing on these new developments, Duschl, Hamilton, & Grandy (1990) wrote a compelling argument for the need to have a joint research effort in science education involving the philosophy and history of science along with cognitive psychology. They point out that cognitive science represents the nature of an individual's knowledge in terms of schemata and that this is analogous to frameworks of knowledge justification in the philosophy of science. Furthermore, they point out the similarity between a cognitive view of learning (i.e., schemata restructuring leading to conceptual change) and scientific discovery as illuminated by philosophers and historians of science (i.e., the logic of discovery). Thus, in theory these three areas ought to be mutually illuminating. I heartily endorse their position, but the historical issue of discovery compels the research community go one step further. Duschl et al. (1990) rightly argue that science education can benefit by examining the cognitive concept of conceptual change in the historical and philosophical lights of discovery and justification. However, what is forgotten is that discovery always takes place in a social and cultural milieu.

Clearly conceptual change in the science classroom takes place, and models of conceptual change (e.g., Posner, Strike, Hewson, & Gertzog, 1982) have helped educators understand and improve learning. The problem is that current thinking about conceptual change is excessively rationalistic and thus limited. In this paper I argue that current thinking needs to be counterbalanced by contextual constructivist ideas (Cobern, in press). As an example of using contextual ideas, I will draw from the social study of science.

The Social Study of Science Education

An external sociological perspective on scientific discovery involves the sociological study of cultural milieu in which scientific ideas arise. If the science education research community has found it helpful to draw upon the history and philosophy of science, I think they will also find it helpful to draw upon the study of cultural issues in the development of science. Without ignoring the achievements of conceptual change research, one can suggest that a cultural perspective[1] on science learning offers additional insight. For example, it may be found that many students resist scientific ideas for reasons similar to those that led many 16th century geocentrists to resist heliocentrism. Bare in mind that one scientist trying to convince a colleague, or even a scientist from another field, is not the same as trying to convince those outside the scientific community. Nor is teaching evolution at the secondary level, for example, anything like a biology professor and graduate students discussing the fine points of evolutionary theory. To the contrary, it is very much like Darwin presenting the *Origin of Species* to a public who historically held a very different view of origins. For the biologist and graduate student the fundamental questions of Darwin's day have long been satisfactorily answered, but not so for the public outside the scientific community including the young science student. It is thus appropriate for the science education researcher to ask about the culture of science classrooms and curricular science *vis-a-vis* the cultures from which students come. It is appropriate to ask about the questions that students deem essential and what those questions mean for science learning.

For some time now, I have been concerned that science education assumes too much about students. I have in mind world view, the "culturally-dependent, implicit, fundamental organization of the mind... composed of presuppositions or assumptions which predispose on to feel, think, and act in predictable patterns" (Cobern, 1991, p. 19). At a minimum science education appears to assume that students share with scientists particular worldview presuppositions about what the world is like, what questions are important, and what methods ought to be used in pursuing answers. Presumably, these shared presuppositions are forged in elementary school. We forget, however, that students live in multiple worlds: the worlds of family, community, peers, and school (Phelan, Davidson, & Cao, 1991). These worlds with their different orientations interact, yet school rarely acts to help students deal with the interactions. As noted by Linn & Songer (1991), students tend to compartmentalize knowledge. The result is that they simply do not deal with the interactions among their worlds, leaving their education permanently impaired. Education for the majority needs to be broadly construed to incorporate students' several worlds, thus facilitating the integration of knowledge.

My point is that while science education researchers are beginning to see that the initial constructivist views of learning were excessively rationalist, the overall view of science learning as conceptual change is still too narrowly conceived (Strike & Posner, in press). The social study of science education is a young field, but it is here that one finds interesting examples of research on broader views of learning (Bloom, 1991; Cobern, 1991; Gauld, 1989; Kawasaki, 1990; Millar, 1989; Ogawa, 1989; Solomon, 1989). Another field of interest is Atwater's (1991) multicultural approach to science education. Her focus is more on interpersonal relationship and learning styles as cultural factors than on cognition. Obviously, there are many factors of culture. However, I agree with Ogawa (1991), "the American approach to multicultural science education is problematic. It seems to me that the movement encourages 'universal science for all Americans' without ever considering the possibility of multi-sciences," where multi-science refers to science in various contextualizations. The approach from the social construction of knowledge recognizes that science does not exist disembodied any more than do students. The collaborative effort that joins the history and philosophy of science with cognitive studies is welcomed because of it recognizes the need for a broader approach to science learning - but, it does not yet go far enough.

Conceptual Change

Models of conceptual change are based on the critical elements of prior knowledge and conceptual conflict. As noted by Garrison & Bentley (1990, p. 21), "students' prior, reasonable and highly verified concepts of natural phenomena provide the prior knowledge base for all subsequent learning about such phenomena." When new knowledge and prior knowledge are similar, the student is able to interpret the new knowledge in a way expected by the teacher. The student's knowledge grows smoothly. In Piagetian terms, this is assimilation. It is weak restructuring in cognitive terms. However, when new knowledge and prior knowledge are quite dissimilar, as is typically the case between commonsense science and formal science, conceptual conflict occurs.

About conceptual conflict there is no doubt, prior knowledge is tenacious and poses a formidable challenge to instruction. The successful interpretation of new knowledge, as per the teacher's intentions, requires accommodating the new knowledge within the prior framework, or in cognitive terms, the radical restructuring of prior knowledge. Models of conceptual change applied to teaching suggest that instruction must accomplish three things for conceptual change to occur. Instruction must enable a student to see that science conceptions are more intelligible, plausible, and fruitful than his or her own priorly held conceptions. What confounds the science teacher is not that some students fail to learn, but that students either remain unconvinced (Lawson & Weser, 1990; Lawson & Worsnop, 1992). Or, they have interpreted a new concept in a fashion unintended by the teacher (Osborne, Bell, & Gilbert, 1983). Even graduate level science students have been shown to hold concepts that vary considerably from what is considered scientific orthodoxy (Clement, 1982). As far back as 1978, Hawkins observed that,

> reasonably patient explanation is no cure... we are up against something rather deep in the relation between science and common sense; we are up against a *barrier* to teaching in the *didactic* mode which has hardly been recognized, or if recognized has been seen mainly as a challenge to ingenuity in teaching rather that as a challenge to a deeper understanding of human learning. (1978, pp. 5 & 7; emphases added)

What is the barrier? Here we are well advised to listen to the radical constructivists' insistence that learning means interpretation (Wheatley, 1989). Learning is not like photography, but like impressionistic artistry. As Ausubel says, the only real learning is meaningful learning. We have learned something when it makes sense to us. If learning occurred by transmission, students would either have the concept or not. What they would not have are idiosyncratic versions of the concept.

Surely an inability to make sense of a concept within the context of one's own background is at least one type of barrier. However, by holding to an exclusively rational perspective on conceptual change, science educators fail to appreciate the role of interpretation and personal meaningfulness. Moreover, the rationalism is exclusive. It is scientific rationalism and nothing else. Excessive scientific rationalism fails to understand that students have different ideas "precisely because the pursuit of scientific knowledge is not the only or even the most important goal [student ideas] subserve" (Hills & McAndrews, 1987, p. 216). Again, insofar as they go models of conceptual change have been helpful (e.g., Clement, 1987). Now, let research push conceptual change into a broader arena.

Internalization vs. Conceptual Change

The science educator is caught on the horns of a dilemma. Those who have acquired a scientific viewpoint find it much easier to understand new scientific concepts because such concepts make sense in light of the person's scientific viewpoint. However, those most in need of learning scientific concepts often lack the very scientific viewpoint that makes scientific concepts meaningful. Of course, as some teachers do, one can always drill students on concepts until they are memorized even without a scientific viewpoint. However, in documents such as the AAAS (1989) *Science for All Americans* it is evident that educators consider scientific literacy to be much more than the simple acquisition of a minimum number of scientific concepts. Why?

To formulate an answer I want to follow Garrison & Bentley's (1990) example and paraphrase Wittgenstein's (1958) argument against the possibility of anyone ever developing a purely personal language. I begin with the question, what does it mean to understand science? Answer:

P_1: I can only claim to understand a concept of science when I understand those prior concepts that justify the first concept. In turn, I can only claim to understand the prior concepts when I understand their justification.

Unfortunately, this proposition results in an infinite regress, and as C. S. Lewis (1947, p. 91) so elegantly wrote, "it is simply no use trying to see through first principles... If you see through everything, then everything is transparent. But a wholly transparent world is an invisible world. To see through all things is the same as not to see." An infinite regression is the same as "not to see," thus, following the lead of both Lewis and Wittgenstein:

P_2: Science is more than a system of concepts. Science is a set of first principals or presuppositions culturally determined.

P_3: These presuppositions determine what scientific concepts will be like, and there is nothing prior to those presuppositions.

P_4: Therefore, an understanding of science is not achieved by acquiring knowledge of a hierarchical set of concepts, but by acquiring the presuppositions that support the hierarchy.

Understanding is made possible by a foundational set of presuppositions - but, these are culturally determined. Thus, science itself is fundamentally an issue of culture. It requires learning to see the world in a new and very different way.

This discussion serves to further clarify the science teacher's dilemma. To break out of the dilemma, Garrison & Bentley (1990) use Kuhn's (1970) explanation of how a scientist becomes a member of a new paradigm. They argue that one cannot learn a new vision, but that one internalizes exemplars of the new way of seeing. For example, motion on an air track can serve as an exemplar in physics, but not as a device for explaining a concept. It is an exemplar to the extent that it helps students visualize motion as Newton visualized it. Internalization of the exemplar is the result of persuasion. Here Garrison & Bentley (1990, p. 30) offer an amusing quote from Wittgenstein on reasoning with someone who has a fundamentally different way of seeing things, "I said I would 'combat' the other man - but wouldn't I give him *reasons*? Certainly, and how far do they go? At the end of reasons comes *persuasion*."

Why persuasion? Because, the acquisition of a scientific viewpoint is not at heart an epistemological issue, nor is it a simple matter of rational conceptual change. Models of conceptual change are epistemological models that assume a common starting point, or reference point. Garrison & Bentley (1990) correctly observed that the acquisition of a fundamental viewpoint is an issue of persuasion and internalization, rather than instruction and learning due to the lack of sufficient common ground. In my view, however, Garrison & Bentley (1990) expect too much of exemplars. Exemplars are derived from a culture to represent the same culture. They do not bridge cultures. On the other hand, a metaphor is a language device that presents an exemplar in the language of a different culture precisely for the purpose of bridging the two cultures. There is a classic example in cosmology. Many people find it difficult to visualize the universe expanding in all directions but with no center of expansion. Arthur Eddington suggested a metaphor, the expanding universe is like an expanding balloon. "Pretend that space is two-dimensional and that the stars and galaxies are dots on the surface of an expanding balloon. From the point of view of any one dot, the other dots are moving away from it in all directions, yet no dot is the center" (Lightman, 1989, p. 97). This metaphor is remarkably effective because it uses an ordinary, well known object from one culture to demonstrate a very different way of seeing. A point I wish to emphasize is that Eddington was able to create this metaphor because he was conversant with two cultures. Garrison & Bentley (1990) speak of science as a second culture, but they fail to see that cultures can be bridged. To use Hills' (1989) colorful phrasing, they have not moved from science education as a matter of "domestic affairs" to one of "foreign affairs."

It is not surprising that science education researchers fail to see science education in terms of foreign affairs. The philosophers and historians of science most influential among science educators are philosophers and historians of domestic affairs. For example, Kuhn (1970) acknowledged that science is influenced by factors beyond the community of scientists, but he does not expand upon this influence. Kuhn's,

> scientists are not represented as being influenced by the general conceptions of nature, man, God, society, and history that inform the thought of their age, or as ideologically involved in social or political issues. His scientists confront nature and other scientists. (Greene, 1981, p. 5)

Once science is viewed in cultural terms as exemplified by Greene's work on Darwin, conceiving of science education as a matter of foreign affairs becomes quite natural. One begins to understand why metaphors can communicate what exemplars alone cannot. This is a rich field for research, however, a thorough discussion of metaphor is beyond the scope of this paper. Instead, I wish to continue with a particular metaphor, *foreign affairs*.

Two Epistemological Foundations: Creationism[2] and Positivistic[3] Naturalism

A typical biology textbook begins its coverage of evolution with Darwin and his masterpiece, *On the Origin of Species by Means of Natural Selection*. The chapter may include a few historical references, but a typical chapter on evolution will focus on Darwin's observations during his voyage aboard the Beagle and the supporting concepts of "struggle for survival" and "natural selection." The discussion then moves on to evidences for evolution - all in good logic of justification fashion. In the late fifties and early sixties, some scientists and educators grew concerned about the widespread lack of acceptance of evolution by the public. The battle was joined, "A hundred years without Darwin is enough!" The Biological Sciences Curriculum Study (BSCS) sought not only to increase the amount of evolution taught in high school biology. BSCS sought also to infuse the biology curriculum with evolutionary concepts following Dobzhansky's (1973) dictum "nothing in biology makes sense except in the light of evolution." The years since have seen the amount of evolution in science curricula go up, then down, and now appears to be on the way back up.[4] On the other hand, the public's attitude toward evolution appears to have remained rather constant.

Regardless the concern that some express over the public's understanding of evolution, one cannot deny that evolutionary theory has had a profound impact on Western thought. We are not the Europeans and Americans of 1859. However, neither are we all evolutionary biologists, let alone scientists in general. Darwin was not then, and is not now, the only influence on Western thought. Though evolutionary theory is not resisted in 1992 the way it was in 1859, we are still interested in many of the same fundamental questions. For example:

1. What is the essence of Nature?

2. How do we account for the fact of life rather than no life at all?

3. What does it mean to be a human being?

4. In what sense, and to what extent, are human beings different from other living things?

5. What is society?

The relationship between evolutionary and religious thought has often been stormy. In the wake of creation science challenges to the science curricula of public schools, educators have tried to persuade the public that evolutionary and religious thought are distinct entities that need to be kept separated (e.g., California, 1990).[5] To the contrary, I do not believe that evolution can be taught effectively by ignoring significant metaphysical questions. One addresses these issues not by teaching a doctrine, but by looking back historically to the cultural and intellectual milieu of Darwin's day and the great questions over which people struggled.

The Thirty-Year War ended in October 1648, with the signing of the Peace Treaty of Westphalia. "The supremacy of Christian theology in European life was over. The age of Faith, the Middle Ages, had run its course" (Jaki, 1983, p. 11). For centuries, the fundamental questions of life had been answered by a Christian worldview, which presented a unified view of knowledge and belief grounded in a theology of creation. The cosmology of the Christian worldview was based on the doctrine of the plenary inspiration of Scripture, which taught that Nature was the purposeful creation of God. Moreover, people drew from this the inference that Nature was essentially static. The Christian worldview had a linear sense of time that had both a beginning and an end. The Biblically based sense of linear time, however, did not necessarily involve the view that the state of human existence was ever progressing (Greene, 1981). The notion of "progress" though based on a linear concept of time was to come much later, and indeed was a notion critical in the development of evolutionary theory.

For the purposes of this paper, even a brief account of the intellectual and cultural history of the Renaissance and Reformation is not really needed. Suffice it to say, the religious wars that followed the Reformation dealt a crippling blow to the certainty that the Church and Christian worldview held for people throughout the Middle Ages - a certainty that was already in a much weakened condition (Cobern, 1992). The 1648 Peace Treaty of Westphalia ended the religious warring, and it also marked the end of the decline into uncertainty. The Christian worldview had long been without significant challengers until the skepticism and uncertainty of the 17th century gave birth to positivistic naturalism. In this view, certainty of knowledge could be attained with an empiricism restricted to measurable characteristics and secondary (or natural) causes. In the words of E. A. Burtt:

> The world that people thought themselves living in - a world rich with colour and sound, redolent with fragrance, filled with gladness, love and beauty, speaking everywhere of purposive harmony and creative ideals - was crowded now into minute corners of the brains of scattered organic beings. The really important world was a world hard, cold, colourless, silent, and dead; a world of quantity, a world of mathematically computable motions in mechanical regularity. (1967, p. 238-239)

For those who chose it, positivistic naturalism re-established certainty of knowledge, but one had to accept a diminished view of both religious and humanistic concepts. With the philosophy of Descartes, one sees the beginning of a mortal epistemological struggle between creationism and positivistic naturalism. Early positivists like Descartes were clearly still thinking within a Christian framework. Even Darwin himself as late as 1860, showed the influence of Christian thinking:

> I had no intention to write atheistically. But I own that I cannot see as plainly as others do, and as I should wish to do, evidence of design and beneficence on all sides of us. There seems to me too much misery in the world... On the other hand, I cannot anyhow be contented to view this wonderful universe, and especially the nature of man, and to conclude that everything is the result of brute force. I am inclined to look at everything as resulting from designed laws, with details, whether good or bad, left to the working out of what we may call chance. (quoted in F. Darwin, 1888, vol 2, pp. 311-312)

With the *Descent of Man*, all had changed.

Since Kuhn (1970), the philosophers of science have been saying that theories of science are always underdetermined, and so it was with evolution. It was not enough for Darwin to make the observations he did. For example, there had long been explanations for fossils within the creationist perspective. Without compromising the genius of Darwin, one has to recognize the influence of the intellectual and cultural state of affairs during his lifetime. The West was still dominated by Christian thought. Positivists shared important elements of creationist epistemology such as the requirements of evidence and experimentation, the canons of proof. The West, however, was no longer a Christian civilization. Darwin was born into an age of transition where long held ideas had been weakened. Of particular significance to Darwin were presuppositions concerning Nature.

Newton argued that a static Nature was composed of particulate matter in motion. To others, that was more a description of a changeable Nature than a static one. Herschel demonstrated that the stars were not fixed after all, but moved. By the 1800s, the accepted assumption of a static Nature was not nearly as tenable, as self-evident, as it had been.

By the 1800s, the West had witnessed remarkable scientific progress in providing a mechanistic understanding of natural phenomena. Moreover, Darwin's day was a time of unprecedented economic expansion, a time when laissez fair capitalism was the rule of the day. Competition was the ethic of the capitalistic marketplace that provided all the change and progress. In 1850, Joseph Paxton built the Crystal Palace in London to showcase the scientific and technological achievements of *modern* Europe. This was indeed an age of change and progress, and this was the backdrop for Darwin's accomplishment. Could these ideas of mechanicism, competition, change, and progress be applied to the world of organic life? If only there were a mechanism...

I am not saying that these were the literal thoughts that led Darwin to the concept of natural selection or that he even had such thoughts. However, he was not a hermit. This was the environment in which he thought and reasoned. Though what I have written is the barest of descriptions for this rich piece of intellectual and cultural history, it is sufficient to make the point that one can describe Darwin's theories as science, but not his embrace of positivistic naturalism. Yet the first makes no sense without the second. To come again to the classroom, understanding evolution requires no less now then it did for Darwin. To understand evolution one must be able to see the world as it is seen by positivistic naturalists - the worldview of evolutionary biologists and of many scientists in general. That is not, however, the worldview of many students. Thus, my position is that the teaching of evolution needs to begin with the very metaphysical questions that were so troublesome in Darwin's day: what is the essence of Nature, what is life, what is a human being? How do religion, philosophy, and science inform our view of the world? These questions are not amenable to simple, didactic teaching. One struggles with these questions, and a teacher who desires to help students must first have an understanding of student views. That is the only way a teacher is able to explain a new way of seeing the world to students accustomed to a very different way of seeing. This returns us to the concept of metaphor and the bridging of cultures. For example, the "two books" metaphor (the book of Scripture and the book of Nature) has long been a powerful device for helping religious students understand the relationship between science and religion (Van Till, 1990). Finally, there is the issue of persuasion. Returning once more to Wittgenstein, "I said I would 'combat' the other man - but wouldn't I give him *reasons*? Certainly, and how far do they go? At the end of reasons comes *persuasion*" (quoted in Garrison & Bentley, 1990, p. 30).

Science Education as a Foreign Affair

Studying the cultural history of Darwin's day prepares one to take a contextual or cultural constructivist approach to the teaching of evolution - the foreign affairs approach. Evolution is a good example for a discussion on foreign affairs because it is so widely rejected and misunderstood by the public. It is also very clear that evolution involves a non-commonsense way of looking at nature and human beings. Also, more is known about Darwin and the intellectual and cultural history surrounding the concept of evolution. However, one can imagine the chemistry teacher saying, "Yes, but my next lesson is on oxidation-reduction equations, so what can this discussion possibly mean for me?" I do not think it means very much if one insists on conceiving of science education as a topic to topic affair. Instead, if one thinks of chemistry in terms of the *big ideas* that have changed our view of reality, then the discussion means a great deal. In fact, the discussion suggests that attacking a small concept in terms of a superordinant conceptual framework, is a good strategy. One might then adopt the Duschl et al. (1990, p. 234) suggestion concerning the context of discovery:

> A suggestion would be to use the context of justification whenever the development was within normal science and the context of discovery whenever it was revolutionary science. Another suggestion would be to use the context of justification whenever new theory requires only weak restructuring on the part of the student, and the context of discovery when it requires radical restructuring. Perhaps these two suggestions converge, and any historical revolutionary episode corresponds to a radical restructuring on the part of the student, but this remains to be demonstrated.

I share the suspicion that there exists a correspondence between historical revolutionary episodes and conceptual change by radical restructuring, though it has yet to be demonstrated. I am suggesting first that historical revolutionary episodes can provide an effective device for organizing science curricula. Second, I am suggesting that the history of science alone does not provide an adequate description of such episodes, but that one must in addition look to intellectual and cultural history. In this regard, I am persuaded that one of the best things that could happen in pre-college science education is the elimination of the strict separation of the natural sciences from the social sciences and the humanities - but that is a subject for another paper. Third, one must not fail to take into account the multiple worlds of students and what those worlds mean for how a student sees the world *vis-a-vis* what the science teacher is trying to teach. This is a contextual constructivist approach to science teaching. It means one should not ignore the cultural context on which a student interprets new knowledge. It means that the social study of science will be at least as helpful to science educators as are the history and philosophy of science. It means that science teachers will have to deal frankly with issues they have long preferred to avoid.

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ENDNOTES

1. My use of the term *culture* is in reference to "webs of significance" (Geertz, 1973, p. 5) which enable one to make sense of the world. I agree with Outram (1990, pp. 327-328), "Even the assumption that culture is relatively coherent is under debate. Contemporary critical theory has now posed a major alternative view: culture as multiple discourses that may occasionally come together in large systemic configurations, but that more often exist together within dynamic fields of interaction and conflict.

2. In today's climate, the term *creationism* has acquired an incendiary quality. That is unfortunate because the term has a rich history that does not deserve the derision precipitated by its modern relative, *creation science*. As I have argued elsewhere (Cobern, 1992), creation science is more of a product of the 19th century intellectual tumult caused by two competing views of nature. I use *creationism* in its historic sense: the earth and its inhabitants are the intentional, purposeful creation of God. This is a superordinant, metaphysical concept which has significant implications for epistemology and science (e.g., Foster, 1934). Creation science, however, is an ill-advised attempt to make creationism a concept within science.

2. Following the example of Gillispie (1979), *positivism* is not used here in the restricted sense of the philosophy formally known as logical empiricism or logical positivism.

3. The ups and down of evolution can be seen in the California science curriculum changes over the last several years.

4. If evolutionary and religious thought have no relationship, one has to wonder what would ever possess an eminent evolutionist such as Gaylord Simpson to write a book titled, *This View of Life: The World of an Evolutionist*?