Hearts and Minds in the Science Classroom: The Education of a Confirmed Evolutionist

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Abstract

This study traces a heuristic inquiry process from the point of view of a science educator, from a secular-humanist background in the northern United States, attempting to better understand and appreciate a major aspect of religious-influenced culture in the southern United States which has a major bearing on science education in the region. The intellectual and emotional viewpoints of selected scientists, science educators, science teachers, and prospective science teachers are examined regarding the relationship between their orthodox Christian religious beliefs and biological evolutionary theory. We view the prospect of teaching evolution to students with such a religious commitment as a prime example of the severe limitations of cognitively-oriented conceptual change theory. We also view conflicts between religion and science regarding evolution as a bona fide example of a multicultural issue in education. These theoretical perspectives are inconsistent with the common tendency among science professionals to view or treat orthodox Christian students in a manner unconscionable with others—to disrespect their intellect or belittle their motivations, to offer judgments based on stereotypes and prejudices, to ignore threats to personal self-esteem, or to deny the de facto connection of some scientific conceptions to the morals, attitudes, and values of individuals with such religious commitments.

Introduction and Theoretical Background

Evolution, Religion, and the American South: Recent History and Current Status

Biological evolutionary theory is one of the cornerstones of modern science learning. "This view of life," as the basic tenets of Darwinism are fondly called by Stephen Jay Gould (e. g.,
1992), after George Gaylord Simpson (1964), after Charles Darwin himself (1859/1962, p. 484), long ago gained nearly universal acceptance among professional biologists. A vast majority of scientists and science educators have also long agreed that the theory of evolution is so powerful and important that it should be a major component of any coherent science curriculum. The major curriculum projects of the late 1960s and early 1970s strongly advocated a central role for evolutionary theory, as exemplified by the statement in the Biological Science Curriculum Study's "Biology Teachers Handbook" that "It is no longer possible to give a complete or even coherent account of living things without the story of evolution" (Mayer, 1970, cited in Oliver, Simpson, & Anderson, 1989, p. 7). More recent documents which seek to operationally define scientific literacy (e. g., American Association for the Advancement of Science, 1989, 1993; National Science Teachers Association, 1992, 1994) also prominently feature biological evolution.

During the late 1970s and early 1980s, the political power of orthodox Christian religious interests was sufficiently great that evolutionary theory as a legal and public policy issue, which many educators assumed had been laid to rest by the fallout from the celebrated "Monkey Trial" of 1925, was resurrected. Several southern U. S. states, including Tennessee, Arkansas, Mississippi, and Louisiana, legislated against the teaching of evolution or mandated that the alternative point of view expressed in "creation science" literature (e. g., Gish, 1978; Gish, Bliss, & Bird, 1981; Morris, 1976, 1977; Parker, 1980) be granted equal status and time in science classrooms. In other southern U. S. states, such as Georgia (Saladin, 1986), more subtle social, political, and cultural mechanisms continue to operate very effectively on a local scale to greatly discourage the teaching of biological evolution.

The response of the scientific community to these most recent creationist legal challenges was swift, powerful, and highly effective. Books and position papers published by several national organizations concerned with science education defended prevalent scientific views against religiously-inspired critiques (e. g., Hanson, 1986; National Academy of Sciences, 1984) or argued that no truly irreconcilable conflicts exist (e. g., Skehan, 1986). In an unequivocal and highly publicized symbolic statement, 72 Nobel Prize-winning scientists endorsed a legal brief against the Louisiana "balanced treatment" law (Norman, 1986; Palca, 1986). This particular statute, widely regarded as carefully crafted and the most likely of any such laws to withstand legal challenges (Ingber, 1989; Rosen, 1989), was still found by the U. S. Supreme Court (Edwards v. Aguillard, 1987) to be an unconstitutional violation of the principle of the separation of church and state. Nevertheless, scattered incidents in which states or local school districts consider mandating equal time for presentation of "creation science" still occur occasionally in the U. S. (e. g., Aiuto, 1993; "California school board," 1993).

Yet, disbelief in the basic story of evolution and in current scientific theories of its mechanisms is still widespread among the U. S. public, and is most often based on Judeo-Christian religious grounds. A New York Times article ("In search of," 1992) reported that, in a November 1991 Gallup poll, 47 percent of U. S. residents surveyed agreed with the statement that "God created Man pretty much in his present form at one time within the last 10,000 years," (p. 5) while a further 40 percent agreed with the more moderate statement that "Man has developed over millions of years from less advanced forms of life, but God guided this process, including Man's creation." (p. 5) Only nine percent agreed that natural processes now operating have led to the advent of humans over time, without benefit of some sort of conscious, active, ongoing, divine intervention.

Even among college science students, according to a broad-based national study (Almqquist & Cronin, 1988), beliefs about the history of the earth and the origin of human life are more likely to be based on religious doctrine than on scientific theory. This is particularly true in the
regions of the United States in which orthodox Christianity is most prevalent. In the South (as defined in an unspecified way by Alquist and Cronin), for instance, only 29.3 percent of college science students surveyed accepted a broad outline of Darwinian evolutionary processes acting over a long period of time, versus 45.9 percent who see the book of Genesis as a more accurate description of the origin of the current diversity of life.

**Conceptual Change, Multiculturalism, and Science versus Religion**

Excellent historical and philosophical arguments can be made for the centrality of Darwinian theory to biological thought (e. g., Gould, 1977; Mayr, 1982) and for the power of evolution as one of the great general themes in the natural and engineering sciences as a whole (e. g., American Association for the Advancement of Science, 1989). Two powerful intellectual trends in science education, however, suggest that the struggle to teach biological evolution to students from an orthodox Christian or orthodox Jewish background may be futile at best and inappropriate at worst.

One of the most fruitful and widely accepted theoretical frameworks in science teaching and learning during the past decade has been the conceptual change model (e. g., Driver, 1989; Posner, Strike, Hewson, & Gertzog, 1982; West & Pines, 1985), in which school learning is viewed as the process of interaction of a student's prior knowledge and past experiences with ideas presented and experiences gained in the current classroom.

Prior knowledge in the form of internally coherent "alternative frameworks" of any kind can be extremely resistant to change (Osborne & Freyberg, 1985). Well-established religious belief systems, which may conflict with scientific theories, are a prime example of such obstacles. The conceptual change model used in so many research studies has also recently come under criticism for focusing exclusively on cognitive concerns and emphasizing a narrow conception of rationality ("cold conceptual change"); Pintrich, Marx, & Boyle, 1993) while largely ignoring important motivational issues, prominently including students' goals and values. The conflict of evolutionary theory with the religious beliefs of many students is an extreme example of the more general tendency of students to focus on learning perceived to be relevant to "a good life," (Reif & Larkin, 1991) as opposed to the idealized scientist's goal of understandings with optimal explanatory and predictive power.

Another principle which has recently become widely accepted in the science education community is multiculturalism. Specifically, multicultural sensitivity in science teaching is most often suggested as an appropriate response to sometimes problematic differences between students in race, gender, socioeconomic status, or national origin (e. g., Allen-Sommerville, 1994; Bellamy, 1994; Atwater, 1989; Atwater & Riley, 1993).

This study was pursued based on the notion that differences in philosophical and experiential backgrounds between otherwise similar people (e. g., middle-class, academically-oriented, white U. S. citizens with a strong interest in science) can sometimes be so pronounced as to constitute a *bona fide* cultural gap that needs to be painstakingly bridged. Consider the definition adopted in a seminal position paper on multicultural science education: "Multicultural education deals with morality, attitudes, and values . . . controversy inherent in stereotypes and prejudices, and basic needs for self-esteem." (Atwater, 1989, p. 17). In our view, the gulf separating the "world view" (Cobern, 1991, p. 7) of most evolutionists from that of most orthodox Christians is so profound that the same educational principles should apply.

These theoretical perspectives are inconsistent with the common tendency among science professionals to view or treat orthodox Christian students in a manner unconscionable with others—to disrespect their intellect or belittle their motivations, to offer judgments based on
stereotypes and prejudices, to ignore threats to personal self-esteem, or to deny the de facto connection of some scientific conceptions to the morals, attitudes, and values of individuals with such religious commitments.

Approaches to Teaching Evolution

Science educators have taken a variety of explicit or implied philosophical approaches to addressing the classroom implications of the conflict between Darwinism and religion. Some (e.g., Grobman & Grobman, 1989; Volpe, 1984) adopt a crusading spirit and seek to expurgate all mention of religious notions from the science classroom in the name of the higher principle of naturalistic explanation. Others (e.g., Kemp, 1988; Moshman, 1985; Provine, 1994; Seaford, 1990) have urged that teachers use the controversial nature of the topic to its best advantage by explicitly raising and critically discussing “creation science” arguments in class in order to provide a high-interest counterexample of what qualifies as a scientific theory. Others (e.g., Nelson, 1986; Scharmann, 1990; Scharmann & Harris, 1992) suggest that allowing alternative views to emerge in less structured peer discussions is less likely to arouse anxiety in both teachers and students, and therefore potentially more conducive to a rational evaluation of the status of the theory of evolution as an example of scientific knowledge. Relatively few (e.g., Simpson & Anderson, 1992) emphasize the importance, in a pluralistic society, of the science teacher maintaining a somewhat more modest perspective on the role and unique value of the scientific way of knowing.

Recent empirical studies of the effectiveness of instruction in evolution have come to some largely negative conclusions regarding students’ potential for developing a fully scientific outlook on questions about the history of life. Bishop & Anderson (1990) found that a demonstrably greater understanding of the Darwinian theory of the mechanisms of evolution did not translate into a significant change in students’ basic beliefs. Lawson & Worsnop (1992), in a study that explicitly took into account the religious backgrounds of students, found that even those who demonstrated especially good scientific reasoning skills and participated in an expertly designed and delivered instructional program did not change their deep-seated beliefs based on their increased knowledge. In explaining their results, these authors concurred with Grose and Simpson’s (1982) earlier speculation that views on evolution presented in a religious setting (whether in the church or in the home) simply leave a greater and more lasting impression on students than when the topic is taught in a science class.

What makes a scientific understanding of evolution so difficult to achieve, even apart from any conflict with religious teachings? Some intriguing speculations on the psychology of the development of evolutionary beliefs were listed by Keown (1988). First, even the basic facts of macroevolutionary patterns are inherently abstract because they cannot, even in principle, be directly observed. Concepts and theories which, through long familiarity, seem satisfying to a scientist or science teacher may not be so easily credible to his or her students:

How tenable to a concrete thinker . . . is the idea that a protozoan ever changed, even over a long period of time, to become an elephant? How credible is the idea that the bacteria seen in the microscope might have been an ancient forerunner to the human species?

That Eve was formed from a rib of Adam is much more plausible without a background of information, particular kinds of experiences and the structures of thinking that allow the student to see evolution as a reasonable explanation for life’s formation and development. (p. 407)
Furthermore, concepts normally introduced in earth science courses (and therefore, typically, during an entirely different school year than a biology course) are intertwined with a meaningful understanding of evolution. For example, "...how long ago it really was when there were dinosaurs or how much it takes for a mountain to rise and wear away—[these are] ideas we believe, but ideas without understanding in terms of time." (Keown, 1988, p. 408). In Keown's view, the fact that evolution is not explicitly introduced until relatively late in a student's academic program (typically not until a high school or even college biology course) may be the greatest problem of all: "There is an educational understructure to understanding evolution that should be built through our natural science curriculum in the elementary and junior high grades and into the high school biology classes." (p. 407) This suggestion, somewhat ironically, parallels the aphoristic insight on which religious educators have long relied to great effect: "Just as the Twig is bent, the Tree's inclin'd." (Pope, 1735/1963, p. 95)

Science curriculum-makers are thus left in a quandary: the basic notion of biological evolution, plus closely related principles from historical geology, might well have the greatest influence on young minds if introduced early in their intellectual development, when they are least likely to be able to fully understand and appreciate them. Thus, attempts to teach younger students about evolution could easily fall into the trap of long-term authoritarian indoctrination, one of the very tactics that many scientists and educators find so distasteful about the educational practices of many organized religions.

A recent exchange of ideas about the oft-unexamined goals of teaching evolution and the importance of the attitude of the teacher (Cobern, 1994; Smith, 1994) provides a fitting context in which to consider the implications of the varying viewpoints represented below. Cobern (1994) emphasizes the importance of a student's overall world view, particularly in regard to a problematic relationship between understanding of a concept or theory and belief in its truth. Contrary to a rigidly "scientific" (p. 585) view of learning and knowledge, it may be possible to understand evolutionary ideas quite well while still disbelieving them, and a "cultural constructivist" (p. 586) view of learning raises the real possibility that existing beliefs may effectively preclude understanding. Since neither understanding nor belief is necessary or sufficient for inducing the other, there is no logical basis for choosing one or the other as a more important or realistic goal in teaching evolution. In a concise statement of the practical implications of this reasoning, Smith (1994) advises the classroom teacher to "address directly the likely cultural/religious concerns with evolution and do so early on so as to break down the barriers that keep many students from hearing what you say." (p. 596) Our hope for this paper is that the words of our informants, as cited below, will put a human face on a substantial sample of the various world views that can be constructed based on a mixture of scientific and religious influences.

The Heuristic Inquiry Approach

This study followed the heuristic inquiry approach, in which an overtly personal and subjective viewpoint is acknowledged. In this kind of research the emotionally-laden nature of the topics investigated is considered an essential aspect of the data and its analysis and presentation. As Patton (1990) states:

The uniqueness of heuristic inquiry is the extent to which it legitimizes and places at the fore these personal experiences, reflections, and insights of the researcher. The researcher, then, comes to understand the essence of the phenomenon through shared reflection and inquiry with coresearchers as they also intensively experience and reflect on the phenomenon in question. . . . The rigor of heuristic inquiry comes from systematic observation of
and dialogues with self and others, as well as depth [sic] interviewing of coresearchers.
(pp. 71–72)

Participants are referred to as coresearchers in the theoretical literature of this approach in order to emphasize the potential of their contributions to influence the direction and emphasis of the research effort, as well as to provide data relevant to predefined questions or foci. One of the most disconcerting but fruitful events that can happen to a researcher is to realize during a study that some of her or his long-held assumptions need to be re-examined or clarified. In several instances, incisive questions posed spontaneously by the participants to the first author served as an immediate stimulus to a reflective re-evaluation of the basic assumptions and goals of the study.

For two reasons we feel that this approach is highly appropriate for this study of people’s thoughts and feelings regarding biological evolution, religion, and the relationship between the two. First, this topic elicits strong emotional reactions in many people, including several of the researchers (most prominently the first and third authors). In such circumstances, the use of a method which explicitly strives for objectivity is probably futile and definitely presumptuous. Second, the primary researcher/first author was conscious of a profound initial ignorance of the religious points of view on the issues raised. This situation calls for a method which anticipates and values an adaptive process by which specific research questions and methods evolve in response to data gathered and analyzed earlier in the inquiry.

Methods

Participants

Participants in the study, aside from the first author, included a total of 17 people affiliated in various capacities with two large, comprehensive state universities in the southeastern United States. Their participation was voluntary and they were recruited based on two criteria: they must have identified themselves as orthodox1 Christians and demonstrated, by virtue of their current occupation, a strong interest in science and science teaching. The sample was not selected systematically to be representative of any particular population, but we consciously strove for diversity in terms of age, gender, and professional status in the academic world. Most participants were identified as potentially appropriate for inclusion in the study based on existing cordial relationships (in academic and/or religious circles) with one or more of the authors ("network selection;" Goetz & LeCompte, 1984, p. 79). They include two university professors of science, a professor and two graduate students in science education, four high school biology teachers, and eight prospective middle- or secondary-level science teachers (undergraduate or non-traditional graduate students in science education). They include eleven females and six males. All are white and all but one are natives of the southeastern United States.

Data Collection

Initial data for this study were collected during April and May of 1992. Informal, exploratory conversations were held with four of the participants (three undergraduate students and one graduate student), which were documented by retrospective field notes and audiotape dictations, recorded immediately after the discussions took place.

Subsequent data were collected through minimally structured interviews with 15 of the 17 participants, conducted by one of the authors with one or two other participants at a time,
throughout the course of the 1992–93 academic year. Audiotape recordings were made when permission to do so was granted by the participant. Eight interview sessions with a total of 10 participants were audiotaped, while detailed field notes (partially verbatim) were taken in three other sessions involving the five other participants. Interview settings included offices, classrooms and lunchrooms in various university and high school buildings. Interviews were conducted in a naturalistic, emergent style without a formal protocol, although a consistent effort was made to elicit responses addressing three broad “interview guide” (Patton, 1990, p. 283) questions: “What do you believe about evolution, or the history of the earth and of life?;” “How are your beliefs about evolution related to your religious beliefs?;” and “Given your career interest in science, do you feel a conflict between your professional and personal beliefs and values, and, if so, how do you resolve that conflict?”

Five of the participants asked for, and were provided with, readings on the subject of possible conflict between the scientific account of evolution and the book of Genesis. A set of papers (Gould, 1983, 1991a, 1991b; Kass, 1988; Skehan, 1986) was selected, by the first author, to represent the opinions of people with a range of religious views, professional expertise, and conclusions regarding the issue. In summary, these readings express the viewpoints of: first, an agnostic and evolutionary scientist who recognizes an irreconcilable conflict and argues for a scientific view and against a religious one; second, a Jewish religious scholar who recognizes an irreconcilable conflict and advocates the primacy of a religious viewpoint over a scientific one; and third, an ordained Christian (Jesuit) clergyman and practicing geologist who believes that a full reconciliation of scientific and religious viewpoints is possible with regard to the issue of evolution. Followup discussions, audiotaped in all but one case, were arranged to allow these five participants to react to the arguments in these papers and to clarify and expand on how their beliefs or attitudes may have changed since their initial interview.

Data Analysis

All audiotape recordings and verbatim field notes were transcribed, yielding data in the form of a single word processor file resembling a dramatic script in several scenes. This master database was then reformatted as a HyperCard stack by distributing each segment of speech by one of the participants (plus any statement, question or prompt to which it was a direct response) into a locked text field on each of a succession of cards. Each card was also initialized with an editable text field designated for analytic notes. The first entries in these fields were excerpts from interpretive field notes and analytic memos (Strauss, 1987) written by one or more of the authors during the period of data collection. The entire database was then reviewed and coded, by the first author, for emergent conceptual categories. Codes applicable to data on a given card were first added to the analysis field and then used to name a newly created hypertext button, in most cases linking the card to another containing the same code.

In successive iterations of the analysis, the data were traversed in various sequences corresponding to hypertext paths controlled by a succession of identically coded buttons. Many codes were merged and some eliminated until a set of central categories remained that were judged to encompass the major issues raised and viewpoints expressed by the participants. These included: naive assumptions related to provincialism; personal communication problems; scientific fact and theory; reality, plausibility, and importance of knowledge; current teaching practice; ties between intellectual and emotional beliefs and between professional and personal lives; conceptions of intellectual integrity; challenge, change, and conceptions of open-mindedness.

A tentative flow pattern for the discursive analysis below was then constructed by program-
ming a procedure (a button script) to compile raw data segments successively to a single file, in an order determined by the pattern in which the database cards were traversed in hypertext space. This yielded a document which may be described as a script of a composite “conversation” among the participants surrounding each major issue. These sequences were then edited and an interpretive gloss added.

Researchers’ Viewpoints and Biases

The multiple authorship of this paper reflects the indispensable intellectual contributions of several of the coresearchers, and a concerted attempt is made to cite data representing multiple viewpoints. Nevertheless this paper is, in essence, a narrative of the progress of one author’s personal understanding and awareness, particularly in response to interactions with one of the other authors. For this reason we feel it is essential to preface our results and interpretations with a substantial account of the first author’s motivations for pursuing the study and the genesis of some of the preconceptions and biases which he and the third author held upon beginning the study.

The first author acknowledges several strong biases, generally in favor of biological evolutionary science and against Judeo-Christian religion. In fact, the primary motivation for this study was the recognition that these biases were a significant hindrance to effective communication and mutually respectful interaction with many of his current students.

His early encounters with evolutionary ideas were such intensely emotional ones that he is inclined to describe them in terms usually reserved for religious experiences. The reconstructed history of the Earth and of life, including the general notion of evolution, was a “revelation” to his young mind. He describes being “baptized” upon first encountering the famous dinosaur skeletons at the American Museum of Natural History as a first grader, and “confirmed” the next year when he saw the classic science-fiction movie Journey to the Beginning of Time, whose modern-day scenes took place in a different but easily recognizable corner of the same museum in New York. He has always found the evolutionary account of human origins to be emotionally uplifting and intuitively satisfying (cf. Beckett, 1988), rather than degrading and questionably plausible. Thus he felt a strong intellectual and emotional resonance when some of the first books he encountered as a college student were Gould’s (1977) first collection of popular articles, with its dedication “for my father, who took me to see the Tyrannosaurus when I was five,” (p. 5) and Darwin’s (1859/1962) classic, whose concluding section is introduced by the aesthetic judgment that “there is a grandeur in this view of life” (p. 484).

His view of organized religion in the United States, and of Judeo-Christian Scripture-based morality in particular, has long been sharply critical and occasionally distinctly bitter and disrespectful. He describes owing many basic intellectual attitudes and beliefs to his parents, who were nominally Christian and familiar with nearly every chapter and verse of the Bible (Revised Standard Version) as a work of literature. They helped to instill in him the strong opinion that, while many of the ideas and values stated or implied therein are brilliantly insightful, many more (especially in the Old Testament) are misguided or even pernicious.

Several years later, while working on classifying trilobites in a paleontology lab, he overheard a conversation at the other end of the room between his supervising scientist and a visitor who, presenting himself as a curriculum researcher from California, had requested an interview. It eventually became apparent to the paleontologist that the visitor was covertly tape-recording their meeting and that he had a specific religious agenda in mind, which came to be known as creation science. Several grossly out-of-context quotations from that conversation, regarding the fact that modern evolutionary theorists are not completely in agreement about several aspects of
Darwinism, later appeared in a popular pamphlet designed for use in science classrooms (Gish, Bliss, & Bird, 1981). After the visitor had left, the usually mild-mannered scientist launched into a lengthy and eloquent tirade in which Christian fundamentalists with an active agenda for influencing science teaching were bitterly characterized in various unflattering ways. This experience helped to establish in the first author a self-righteous contempt for the beliefs, values, goals, and tactics of prominent creationists, and, by extension, for nearly any person whose actions or opinions are openly based on orthodox religious beliefs. As later expressed in a popular book, whose writing was directly inspired by several similar experiences (N. Eldredge, personal communication, July 1985), "Creationists tenaciously cling to the wisdom and world view of a Near Eastern culture thousands of years old. . . . So creationism seems to me to threaten the integrity of our children's education, and thus threaten the long-term well-being of our country." (Eldredge, 1982, pp. 22–23)

As a result of these and other experiences and influences, the first author thus began the study with a mindset best described as fear and condescension, rather than respect, empathy or sympathy, toward people (including the third author) who hold such beliefs.

The third author, in stark contrast, is an orthodox Christian who bases his religious beliefs on a view of the Bible as inspired by God and inerrant in its original manuscripts. Raised in a fundamentalist Christian home in Mississippi, his school experiences with evolution were consistently disturbing. His first major encounter with evolution was in a public school, in his ninth grade biology class. His impression of his biology teacher is that she had an agenda for divesting any orthodox Christians in her class of their ignorant notions about the origins of the earth. During his whole ninth grade year, he remembers dreading the evolution unit as it drew closer, and then finding the presentation very distasteful. He and many of his friends had several questions, mostly along the lines of "Does anyone really believe all this stuff?" (cf. Keown, 1988) only to be told that such things would not be discussed in biology. His only choice was to accept the science as dogma and leave it unquestioned. The experience was distasteful enough to convince him to avoid biology whenever possible in the future and to focus instead on the physical sciences.

His second major encounter with evolution was in a required freshman zoology course at a state university in the southeastern U. S. During the first lecture on evolution, several of the students began asking questions about evolution versus creation. The teacher stopped the questioning and announced that her class was a "dictatorship" and that such issues would not be discussed. The third author still had some unresolved questions, however, and attempted to engage his teacher in a non-confrontational dialogue after one of the laboratory sessions, but she refused to discuss the issue. He walked away with the impression that evolutionists were narrow- and closed-minded.

Even his years as a graduate student in science education brought brief skirmishes. At one point, the third author was warned that any revelation of creationist leanings could seriously threaten his progress toward his Ph. D. Graduate studies, however, brought a reconciliation of the issue through an understanding of the philosophy of science. Seeing science as a world view enabled him to compare in a more rational fashion the view of origins constructed by scientists with the view of origins given in Scripture. This world view comparison eased some of the tension in his mind between a scientist's need for evidence and a Christian's need for faith. The process led him to picture himself as a scientific philosopher with a Christian world view and to formulate his current view that the origins debate is a good opportunity to teach students, through the philosophy of science, that science is a very effective, but not the only effective, way of knowing.

The first author sees a strong similarity in spirit, reflected in the subtitle of this paper,
between this inquiry and the autobiographical work of the historian Henry Adams (1918/1973), who also felt it essential that his extensive formal schooling be supplemented by a conscious and disciplined effort to obtain an ongoing informal education at the hands of people with very different experiential backgrounds and perspectives on personal and professional life. As in Adams' case, many of these differences in world view are related to provincialism and to cultural factors related to socioeconomic status. Many of the deficiencies in the first author's initial understanding were framed by a previously unquestioned faith in the inherent value of science and technology, in contrast to Adams' conclusion that he suffered greatly from a relative ignorance of these fields.

Results

Evolution versus Religion as a Hindrance to Professional Communication: Examples from a Conversation with Prospective Science Teachers

The earliest informal discussions that served as the inspiration to pursue a more extensive and focused study occurred when several undergraduate students raised questions immediately following a class session in a science education course focusing on middle school earth science teaching. The topic for the preceding class period had been a survey of common misconceptions held by earth science students, including examples drawn from a recent article on that subject (Philips, 1991). The reconstructed paraphrases of parts of that conversation included below illustrate how quickly and easily people can become simultaneously entangled in a number of important and troublesome issues when discussing the emotionally charged subject of the history of the earth and of life. The opinions and beliefs which emerged in these informal conversations were, surprisingly to some of us, quite varied. These prospective science teachers would likely find plenty of grist for debate among themselves on purely religious issues alone. What they have in common is that they all illustrate worrisome problems for science education in general and teaching about evolution in particular.

Some prospective science teachers demonstrate a simple, honest, and profound ignorance of evolutionary theory, or of biological and geological evidence for evolution. Others have been exposed to these topics but never developed the notion that the subject matter of science and of religion may somehow relate to each other, and therefore may potentially conflict in some ways. As this conversation began:

CHRISTINE: There's something I'm a little confused about in the paper we read [Philips, 1991]. It never occurred to me that “The Earth is 6 to 20 thousand years old” or “The Garden of Eden is where human life began” are “misconceptions.” [p. 22] I've just always known things like that.

DR. J: Well, as I mentioned in class, a less judgmental term is “alternative conceptions”—some of these ideas may not be totally wrong, and people may have some good reasons for believing them, but they don't fit in with what virtually all modern scientists who have studied the issues think, which in this case would be the theory of evolution over a much longer period of time.

CHRISTINE: Like . . . geology and those specific time periods?

Christine's geology class (a corequisite of the aforementioned science education course) had finished a lengthy unit on historical geology earlier the same week. She had, for instance, learned the names of the eras and periods of geologic time, their characteristic flora and fauna as evidenced by fossils, and the numbers of millions of years which represent the major boundaries
between them. This knowledge was, however, inert and unreal to her in the sense that she did not think of it as something known in the same sense as Biblical history and chronology.

In contrast to Christine, some prospective teachers saw a conflict between evolution and religion as not only obvious but having far-reaching implications. As others who had overheard the above conversation began to join in, the discussion quickly became more heated and explicitly personal. As the same conversation continued:

**KAY:** Yes, but a lot more than that. We’re talking humans coming from apes and no God and everything . . .

**DR. J:** Wait, wait, wait . . . I don’t think it’s as simple as that. There’s a lot of middle ground between those “misconception” statements and saying there’s no God. That was settled a long time ago . . .

**GEORGETTE:** I’m surprised that someone with your knowledge doesn’t believe in God.

**KAY:** I’m not surprised at all. You seem to take science pretty seriously and I think it keeps you from seeing what’s important. Sorry, but that’s just the way I see it. *[leaves the room abruptly]*

Contrary to the first author’s [Dr. J.] naive conception at the time of this discussion, the explicit or tacit assumption that belief in evolution logically implies atheism was widespread among the participants. Likewise, more common than he expected was the view that atheism or agnosticism strongly implies undesirable traits in personality or morality. The genuine surprise on both sides of this exchange seems due to the different brands of provincialism characteristic of the southern and northern U. S.—regions historically dominated, respectively, by orthodox Christian and by secular-humanist culture.

Some of these prospective teachers showed an insufficient understanding of the operational definitions of “fact” and “theory” in science and the perception that the tentative and flexible nature of scientific knowledge is a fatal weakness of its method. In the case of the participants in this conversation, this was true despite the fact that modern views of the epistemology of science were stressed in both the science content and science education courses in which they were enrolled. Again, the same conversation continued:

**GEORGETTE:** No, evolution is fine, as a theory and all, but how did it get there? Where did it all come from? That is God’s part.

**DR. J:** Okay, what do you mean by “theory”? *?

**GEORGETTE:** Well, it’s not proven, it’s just an opinion. I know, I know, we’ve heard that nothing in science is ever completely, logically proven, but back in the real world we accept that some things are facts and some just aren’t. And evolution is not.

There is a natural but unfortunate tendency to develop a rather strident tone in discussions like this, perhaps as a result of intense emotional involvement in intellectual disagreements on this subject. It is also common to use rhetorical flourishes in an effort to limit discussion, rather than to express one’s own ideas more clearly or to stimulate contributions from the others in a group. As the same conversation progressed:

**KAY:** You can never know, that’s the point. I think all of the stuff we’re studying in class is fascinating to think about and play with—that’s why I’m here, and that’s why I want to do it with kids. But “science as a way of knowing” is, literally, laughable. I mean, knowledge is only in God and those who know God. It’s laughable, it really is. How can anyone of us claim to know anything through science about evolution, or even about a lot of the physical science stuff?
GEORGETTE: Come on, we really do know some things. We get to know things in different ways, but it's all the same world. I think of science and religion as all part of Nature, all connected. The more you find out, the more religious you become.

DR. J: Well, I've certainly never thought of it that way, but that was actually a pretty common view in the early 1800's—it was called "natural theology".

Last, but perhaps not least, the evolutionist and science educator (Dr. J) caught in the middle of this whirlwind exchange showed an inclination to immediately challenge his students as adversaries, rather than either listening more patiently to their explanations or asking them, in a more dispassionate tone, to clarify or expand on their viewpoints. He also clearly over-intellectualized the discussion (e.g., introducing historical references in the exchange cited above), betraying a lack of recognition of the degree of emotional involvement on the part of many of the others. This can also have a chilling effect on such conversations, either because points are raised that seem irrelevant to many of the participants, or because others may feel intimidated by the tone of such comments.

**Rationales and Strategies of Practicing Science Teachers**

How can the notion of evolution be presented to orthodox Christian students without being so threatening that they will just "turn off" their minds or "tune out" their teacher? The responses of participants who are practicing biology teachers (at the high school or college level) show a wide range of sophistication and subtlety.

One approach is to try to ignore the potential difficulties, denying that there is any real interface between science and religion:

- MS. H: What if they asked you?
- MS. A: Tell them it's not linked—just get the facts.
- MS. B: Yes, teach evolution as a theory that some people believe and that they [students] do not have to believe it as "truth," but just know it for the test and forget it if you prefer. We're supposed to keep science and religion separate, right?

This approach, however, explicitly downplays any role for science as an intellectual process. To these people, the epistemology of science is either unproblematic or irrelevant; "facts" are clear and self-evident and theories need not and cannot be critically judged by any criterion other than individual opinion.

These teachers' actions are closely related to their own personal beliefs, inclinations, and backgrounds. Ms. A admits to "not really believing" evolution herself, on religious grounds. Ms. B sees no conflict between her own understandings of science and religion, but resisted attempts to further probe her attitudes towards issues that cause conflict in the minds of so many others. She seems to identify with students who feel that anything touching on religious issues is simply not the business of anyone outside their family and/or their own religious community.

Another teacher sees her proper role as providing relevant information to facilitate and encourage students to judge the validity of theories, including evolution, for themselves:

- MS. C: Evolution is a theory—a lot of what we teach in science is theory. Theories are based on facts—I encourage them to look at the facts and decide for themselves what is right or wrong. I don't tell them this is how it happened, I give them the facts and let them put it together with Creation. If I tell them scientists have dated rocks back to four
and a half billion years—but that we’re not absolutely sure of the accuracy of the assumptions of the method. They may decide that it doesn’t work for them—that’s fine with me. A lot of the facts that evolution is based on can be looked at objectively—the beliefs are theirs. They can believe all or none of it, but not before looking at the facts.

Only Ms. C, among these three teachers, showed evidence of a willingness to grapple with apparently conflicting ideas in her own life, and this translated to an expectation that her students should be able and willing to do the same.

Another approach taken by two of the participants (one a high school teacher, the other a college professor teaching a mid-level evolutionary biology course) is for the biology instructor to openly acknowledge his personal views, presenting himself professionally as a model of one who has somehow reconciled the two belief systems:

MR. D: I make sure that everyone in my classes knows I’m a Christian, and that I’ve never had a problem with evolution. Any other explicit discussion of religion or the linkage between the two goes on after regular class hours on an individual basis. And a lot of it does go on, given [the very rural county] where I teach. It’s not science, but I feel it’s part of my job. I’m a teacher before I’m a science teacher. I’m a role model as well as a purveyor of information.

DR. E: I start out at the beginning of the first day of class, as I’m sure many other people teaching the same kind of course do, with the quote from Dobzhansky [1973], “Nothing in biology makes sense except in light of evolution.” I then announce, “We are going to talk about why he made this statement.” The next thing I say is, “The author of your textbook is a homosexual and an atheist. I am a heterosexual and a Christian. We are very different people, but we’re both scientists. We approach things very differently, but end up in the same place.”

Mr. D considers the personal well-being of his students ultimately to be more important than their academic life, yet doesn’t let these values alter his basic conception of science or of what should and should not occur in a science class. Dr. E explicitly challenges the presumption, as illustrated by some of the prospective teachers cited above, of a connection between a basic acceptance of evolution and specific religious or moral commitments.

Three of the participants had an unusually strong background in the physical sciences, rather than biology. One is a university professor of chemistry, who teaches introductory courses in chemistry and physics to both science and education majors. Among the prospective teachers interviewed, one is a double major (chemistry and education) and the other has an undergraduate degree in physics. They all showed evidence of a strong sense of the context of their own beliefs and attitudes in relation to science and religion. This combination of personal beliefs is internally consistent in their minds, even if they may seem paradoxical or even self-contradictory to an outside observer. For all of them, the key to a harmonious coexistence of science and religion is their long association with both. Ideas with which they grew up became congenial and trustworthy, while new ideas introduced suddenly by untrusted outsiders might have elicited a defensive reaction.

They all share a basic belief in all or most of the narrative history of evolution, as deduced by geologists and biologists. They find very compelling such evidence as the space-time relationships implied by the fossil record and the patterns of similarity exhibited both by the observable morphology of plants and animals and by sequence comparison data from DNA. They all retain, however, some notion of the necessity for divine design and/or direction, in particular the idea that God actively and consciously gave some kind of added touch of uniqueness (or spirituality, awareness, etc.) only to humans. As they stated in separate interviews:
RANDY: As I understand it, when biologists say "evolution" they mean we came from a single cell—step by step—until where we are now. I don't really believe we all came from a single cell but I don't rule that out. I do see that all organisms change, both short term and long term, you know, like those [peppered] moths and like humans [from apelike ancestors]. We have evolved—the bones may look increasingly human, but I think the first human had to have the capacity for thought. Where did that come from?

TRIPP: There's a big difference between the evolution of man and what went before. It's not that natural selection didn't operate on the ape-men, or whatever, but that can't be the whole story.

DR. F: If you look at the way things work—the properties of a molecule like water that makes life possible, and the conditions for life—if you look at the beauty of creation, the natural world, it's hard to imagine that this could have come about through just time plus chance, it seems to me there has to be a creator, an intelligence behind this. And if you think of the physical world as being an impersonal mechanistic world, if that's the ultimate reality, it's impossible for me to see how human personality could have arisen out of this. I see us as made in the image of God—our nature is a reflection of his creation.

These educators have also consciously analyzed and codified their epistemological stances. As a result of reflection on their experiences with weighing conflicting evidence, and their acceptance of a multiplicity of satisfying ways of coming to understand their world, they offered very clear statements of their positions:

DR. F: I believe that God is the author of both the Bible and of nature and that if these are properly understood they can't conflict with each other. Now, it's possible that at some future time I may find terrible difficulties in reconciling these but at the moment I don't see that big a problem.

DR. J: Let me try to make sure that I understand. You posit as an assumption that neither one can be wrong, so if it appears that there is a conflict, you assume that there is not a conflict and change your interpretation of one or the other? It can go both ways?

DR. F: Right. If the Bible says that the sun rises and if we try to use that as proof that the earth is the center of the solar system then that is a misinterpretation of Scripture. The Bible is not a scientific document in the sense that a physics text is, but I think it's legitimate from a Christian point of view to look at the Bible as a means of interpreting science—interpreting, if you wish, the purpose behind creation. I think there are elements there which can be thoughtfully discussed.

TRIPP: The Bible is The Truth—it cannot be wrong. The Bible is The Truth, in some sense, but not all is included. It contains everything you need to live a moral life, but not science. Science is a special way of finding out about special things—you could say the same for religion. There's no way that anyone could have come up with some of the amazing ideas in physics without a scientific approach, no way, but . . . you don't have to justify religion in any way, its power is obvious to anyone who cares to look. To me there's a simple secret: focus on what we can understand—you're wasting your time (and being blasphemous) trying to find out other things for yourself.

RANDY: My father is a high-school chemistry teacher, mostly, and sometimes teaches biology. I have grown up with science as much as with religion. My room has two huge posters on the wall that inspire me every day—one of Christ and one about Chemistry.

As a scientist who has become actively interested in theoretical as well as practical issues in education, our chemist has extended his reflections on epistemology further afield:
DR. F: I also wanted to say something about constructivism in this regard. My reservation on constructivism is that, pushed to its ultimate, it could be interpreted as saying that we cannot know, whereas if God is who he claims to be in the Bible there are things that we can know and we don't have to construct. On the other hand the evolutionist who claims to be a constructivist has got to allow the students to construct their understanding of religion and evolution in ways that make sense to that person. I mean a true constructivist is not going to be so dogmatic as some of the evolutionists are.

Dr. F is often affectionately described by some of his education colleagues as a “born-again” constructivist, as well as a born-again Christian. In practice he is an advocate of what has come to been called “trivial constructivism” in science education circles, in contrast to the more “evangelical” advocates of radical constructivism. He values constructivist insights for their contribution to pedagogy rather than as an overall epistemology. His critique, however, comes from a theoretical (in this case, theological) perspective instead of a practical one.

Even some professional evolutionary biologists manage to hold very nearly fundamentalist religious views, and one of our participants gave some of the most intriguing views of the range of possible relationships between the personal and professional lives of scientist and/or science teacher:

DR. E: My earliest background was in phylogenetic analysis, “Who is related to whom?” “Bats and rats”—that's what I originally worked with. For instance, how might specific anatomical adaptations have arisen, possibly multiple times? I was fascinated by that. But my other background is as a Christian, and that's the most important part of my life. I actually do couch myself as a fundamentalist, although many people would deny that I am. I do believe that the Bible is God’s word, it is inerrant.

DR. J: I think that my main misunderstanding here has always been that I didn’t realize how central Biblical inerrancy was. I still don’t understand the distinction between inerrancy and literalism.

DR. E: The Bible has been kept intact—there have been word changes, but God has kept the meaning intact. But the Bible is not one literary type. I have a foot over the edge of the cliff here in the direction of denying strict literalism—I may face God one day, and He'll say, ‘You were wrong,’ . . . but I don't believe that God lashes out at people. I'm not really concerned whether I'm wrong or not. My standing with God has nothing to do with my stand on evolution. There's still a tension, it doesn't resolve . . .

DR. J: So your way of achieving intellectual integrity is to move a little bit towards a metaphorical interpretation. But isn't there still a real conflict? I still don’t see how it squares with science.

DR. E: Don't get me wrong—I accept evolution. I accept some things that I’ll never know. I mean, one's eternal and one's not, so if there's a conflict . . . I'm often asked how I can be a Christian and a scientist, or vice versa—scientists ask me, and my Christian friends ask me, and they all assume that I must be compromising both sides, but I'm not, really—I accept that evolution is the mechanism the God used to create life. See, some tension comes from mistaking process for reason, the ‘How?’ for the ‘Who?’ and ‘Why?’

Like the physical science-oriented participants, Dr. E’s ability to live both emotionally and intellectually with insights gained from both epistemological systems stems from his long familiarity with both:

DR. E: I was always excited by science, by Nature, if you will. That has been with me for a long time, and so has the conviction that everything must somehow fit. The
essence of Christianity, for me, is a personal relationship with Jesus. Once you make an initial commitment, a relationship can grow. That applies to Christianity and to science.

Dr. J: What if they grow in different directions?

Dr. E: That might be happening. That possibility will probably always be hanging over my head. My position gets me in trouble with almost everyone I know and care about. In terms of teaching and interaction with both groups of people, I feel tension [clenches his teeth] approaching stress sometimes. I would rather know for sure, but... God wants me to trust him and also my own judgment. I could never give up Christianity but giving up my profession would be almost harder to do.

Dr. E is clearly neither a typical scientist nor a typical orthodox Christian, but his devotion to each of what many would see as entirely separate worlds is intense, sincere, and full of intellectual as well as emotional excitement.

Confrontation, Adjustment, and Self-Esteem

Two of the participants, graduate students in science education, reported that they had undergone significant changes in their own views as a result of the issues raised in an initial interview and subsequent readings (viz., Gould, 1983, 1991a, 1991b; Kass, 1988; Skehan, 1986). At an earlier time, one (Ms. G), a prospective teacher, had expressed the most clearly fundamentalist religious views of any of the participants. She also openly stated a belief that exposing herself or her prospective students to ideas which might contradict religious belief is inherently harmful, not merely uncomfortable. The other (Ms. H) was easily the most enthusiastic of the participants in the initial interviews, eager to share her past success at reconciling evolution with the Bible as both an individual and a biology teacher. These two participants were brought together for a followup discussion because, in previous conversations with the first author, both expressed new insights and doubts which were precipitated by considering some of the selected readings.

Ms. G: So what is your view on all this?

Ms. H: It's changed—I used to teach that evolution and Genesis were OK together and now (recently) don't believe that's true anymore. I'm in a state of confusion. It appears on the surface that everything is pretty-well fitting together, but when you look at the details it doesn't, no matter how much you want to do it...

Ms. G: That's why I ended up with this [points to a notebook], but I could not match it—but I noticed that there was a lot of common ground.

Ms. H: I really thought I could until I read the "Gould Gospel" [1991a]. He's absolutely right. Generally, if you don't look too closely it all fits together fine, but if you look at the "meat" of the thing it doesn't. It's not truthful to tell students, "It's OK—it all fits together" when it doesn't. It doesn't sit well with me to bend over backwards to come up with a sufficiently obscure metaphorical version of Genesis like in here. [points to a copy of Kass, 1988]... What is it that they taught you about evolutionary theory?

Ms. G: Oh, nothing! I'm approaching the whole issue now from the point of view of my earth science learning last year, because that's all I know.

Ms. H: So you don't feel that evolution is untrue? Have you found a common ground? Where do you stand?

Ms. G: I still believe in creation but I don't totally discredit evolution. I am very much open to learn more about evolution. I am still learning it—every time I find something new, it is just an incentive for me to go back to the Bible to find something like it. But, I can accept these things as true if they've found evidence. So I guess that's a fact.
I can also accept things that others [members of her church] won’t accept. I’m not saying they’re true or that they aren’t true. That’s the way I would teach now if I were a teacher.

MS. H: What, exactly, would you have the students do?

MS. G: [opens a notebook] When I hear or read an idea in science, I put it in the first of three columns in my notebook: scientific theories/facts, common ground, and Scripture. Then I would compare notes to facts from the Bible, being careful to maintain the context of the verses. Very often, I find a different way to say the same thing, and it goes in the middle column. Lately I’ve found a lot of common ground—there’s a lot you could teach by just emphasizing the areas of agreement. This would be more personal for the kids—have them write first (to make the shy ones more comfortable), then get them together for small group discussions. Especially if the groups were organized differently each time, they could add to or modify their tables with entries from others.

Ms. G has found in science (evolution and earth history in particular) a new source of intellectual stimulation which does not alienate her from her religious background but broadens her thinking, and, in real way, enhances her world. Ms. H had a starkly contrasting emotional reaction to the intellectual challenge. She now refers to her beliefs and attitudes of the recent past in uncomplimentary terms as “living in a nice little world—I can’t do that any more.” Ms. G sees Ms. H as going through a similar experience to her own of earlier in the year—an uncomfortable period during which “everything I had been taught was called into question,” in her case by a geology course, rather then the detailed study of evolution in biology. Engaging students’ minds with evolutionary ideas as explicitly related to religious ones can clearly have strong affective as well as cognitive effects, which can be positive in one sense and negative in another.

**Forced Choices, Principled and Pragmatic**

One of the participants (the third author), a science educator who has taught chemistry at both the high school and college levels, has a particularly strong background in theology as well as orthodox Christian personal religious beliefs. In contrast to the participating scientists, he is highly skeptical of the possibility of fully reconciling his brands of science and religion while still maintaining the integrity of both systems of belief, along with his own emotional stability. He was another of the participants who read the set of additional readings (Gould, 1983, 1991a, 1991b; Kass, 1988; Skehan, 1986) selected by the first author, and did so in a particularly careful and critical way. His response, given in an extensive followup interview, was impassioned:

DR. I: Many people will argue, such as in the NSTA document [Skehan, 1986], that no real conflict exists because evolutionary history, as described by biologists and geologists, may simply be the means chosen by an all-powerful God to a special end, which is humanity. This goes along, of course, with a non-literal or “metaphorical” interpretation of Genesis. Theistic evolution, as it’s called, is a compromise to such an extent that I think it is unacceptable from both sides. The Bible is effectively stripped of its authority, but scientific theory is also diminished. In fact, if you read the paleontologist’s book [Gould, 1977], the spirit of scientific inquiry in this area is contradicted in a truly fundamental way, by retaining the idea of purpose, of direction.

DR. J: Why does it really matter so much about the beginning, about meaning and purpose? Here’s something you’ve underlined in this article: “Genesis and geology happen not to correspond very well. But it wouldn’t mean much if they did—for we would
only learn something about the limits to our storytelling, not even the whisper of a lesson about the nature and meaning of life or God." [Gould, 1991a, p. 415]

DR. I: That is true if we are God, figuring out and giving meaning to life as we find it. If God is God, and the Bible is true, then the conflict between Genesis and science as taken today is a big problem.

DR. J: But can’t a person develop a reasonable and effective moral system without reference to God or any other religious ideas? What about Dewey [1934]? Can’t a person be “religious” in a very real sense, apart from a belief in the supernatural?

DR. I: Come on, think about the real world. In practice, morality is inseparable from religion. I mean, I hate to think what I would have done when I was a wild and free college kid if I had no fear of God. Think about people. You know this is true.

DR. J: But, philosophically, morality has no necessary relation to religion at all. There’s no need to read meaning into everything [cf. Allmon, 1990]

DR. I: But where does meaning come from, if not from God? If we are essentially God, then we can reason and do as we like. If not, then the conflict is very real and very important.

As with the prospective teachers cited earlier, it became clear that Dr. I grew up in a culture that sees orthodox Christianity as absolutely the only effective source of morality. The most important point that he emphasizes here is the very real practical value of religious faith. He would claim, in fact, that the practical value of evolutionary theory in particular (as opposed to most other major concepts in science, particularly in chemistry and physics) is so minimal as to pale by comparison. It is for this reason, in addition to strong philosophical convictions, that he has come to the conclusion that religion must ultimately win out in his life whenever it comes into apparent conflict with science.

Dr. I was also the first (but certainly not the last) of the participants to cause some real dissonance in the mind of the first author by questioning, in a forceful but civil manner, the tacit values and assumptions that the secular humanist view of life brings to this marketplace of ideas:

DR. I: Would you claim that science as a way of knowing is better than religion?

DR. J: [hesitates for a split second] Yes. I’d never thought about it in exactly those terms before, but now that I think about it, there’s not much doubt in my mind.

DR. I: Then you would never get anywhere teaching about much of anything in science to the kinds of children we’re talking about. And neither would the evolutionists who are known as such eloquent writers. You get statements here [points to a copy of Gould, 1991a] like this: “the nonsense of... Biblical literalism will never go away, so long as cash flows and unreason retains its popularity.” [p. 403] That’s the kind of language that’s so uncalled for. It’s alienating, spiteful, and hurtful. If you’re going to assail someone’s deeply held faith, do it gently, with respect.

DR. J: But these kids’ minds are being restricted, crippled, by something that they don’t really understand, that’s been planted in them almost mechanically. Here’s something from the radio show the other day: “Even if they don’t understand, they never forget. That’s the premise that many organizations work on. Give us your children until they’re six or seven, and we’ll have ‘em forever. Parents believe their main job is bringing up children according to biblical teaching: God says ‘train up a child in the way they should go’ [Proverbs 22:6, King James Version], and ‘train’, that word ‘train’ is talking about discipline—from the time they’re little—as the twig is bent, so groweth the tree”’ (National Public Radio, 1992). That’s very true, I agree, and it’s scary to me.

DR. I: That’s because you haven’t experienced the alternative, for many kids, which is a total lack of direction, nothing to hang on to. What you’re not seeing is that, for people like me, and for many others I know, Christianity is an enabling force rather than a
restrictive one. I'm a better scientist and a better science teacher as well as a better person because my faith gives me the strength and confidence and inspiration to get on with my life when things get tough. And that's the way it's always been in my family for generations.

DR. J: I suppose that's an experience which it's awfully hard to understand if it's not your own.

DR. I: Well, at the bottom of it all is the fact that people make choices. They choose whether to orient their life philosophies around faith or around something else like science. Most orthodox Christians have chosen to believe in God's words as they are presented in the Bible, and if that contradicts with science, so be it. They have found faith more trustworthy than science, and they exercise their intellectual independence by choosing to trust in God through faith rather than choosing to trust in what they see in facts.

Science educators from a secular-humanist cultural background, as exemplified here by Dr. J, often take a condescending attitude towards orthodox Christians in general and an openly hostile attitude toward those, like Dr. I, who pursue an advanced degree and high-level professional involvement in science education. Furthermore, science educators from an orthodox Christian background, as exemplified here by Dr. I, often come into the origins arena defensive, impassioned, and primed for confrontation.

Science and Secular Humanism as Intellectual Comfort but Practical Hypocrisy

In followup discussions with some of the prospective science teachers, other "articles of faith" of science, science teaching and of the secular-humanist view came under formidable attack as well. Some dearly-held tacit beliefs were exposed as, at best, critically unexamined and, at worst, hypocritical.

ALICE: You say you're looking for a teaching approach which will encourage open-mindedness. What exactly is "open-mindedness"? Are you doing this because you have some doubt yourself? Are you open to changing your own beliefs as a result of all of the questions you're asking of people?

DR. J: Well, yes and no. It's hard for me to conceive of coming to doubt evolution. It's possible to conceive that I could come to positively believe in a God, or even Christianity, but very unlikely.

ALICE: You're a pretty extreme case—you were a trilobite and snail major, or whatever (both laugh) and now you're in the business of promoting science teaching. And I doubt if evolution is nearly as important or as central to you as their faith is to a fundamentalist. And you're going to ask them to give up their life for some trilobites, or snails, or even dinosaurs (whatever)! Don't you see how that feels? Could that be changed by something you learned in a class at school? I'm praying for you.

GEORGETTE: Talk about theory and practice! You have a baby girl, right—how old is she now?

DR. J: A year. And she's wonderful, and no less so because she wasn't specially created by God. (brandishes index finger in mock menace)

GEORGETTE: And you can look at her and tell me truthfully that you don't act as if there's a soul, or spirit, or mysterious meaning to life? I'm very surprised.

DR. J: There's not a conflict between something, including yourself or your family, being wonderful—think about the actual meaning of the word—and believing that it is somehow the product of entirely natural forces. Things can be wonderful or even mysterious without being supernatural. But, you know, as far as second-to-second or minute-to-minute gut reactions to someone you love, I think you're right.
Discussion

It seems already widely accepted in science education circles that instruction of orthodox Christian students in evolution is very likely to lead to frustration and failure from a teacher's point of view. Many science teachers, being people of good will but blinded by scientific hubris, unwittingly contribute to this by quickly alienating a large proportion of their student audience by presenting evolution dogmatically and/or as explicitly opposed to religion.

At a more practical level, perhaps the most important distinction concerning evolution which teachers should keep in mind is that between evolution as fact and evolution as theory. The most frequent criticism of evolution from a orthodox Christian point of view is that it is "only a theory" (cf. Anderson & Kilbourn, 1983). A teacher's most appropriate response would take this distinction into account, as Gould (1983) admonishes:

Well, evolution is a theory. It is also a fact. And facts and theories are different things, not rungs in a hierarchy of increasing certainty. Facts are the world's data. Theories are structures of ideas that explain and interpret facts. Facts do not go away while scientists debate rival theories for explaining them. Einstein's theory of gravitation replaced Newton's, but apples did not suspend themselves in mid-air pending the outcome. And human beings evolved from apelike ancestors whether they did so by Darwin's proposed mechanism or by some other, yet to be discovered. (p. 254)

In the case of all of the participants cited in the results above, the importance of abstract scientific theory is revealed not by its prominence but by its conspicuous absence. None of the 17 people ever mentioned specific biological concepts and theories of mechanism, such as genetic mutation, natural selection, etc., in any of their arguments. In a few cases this might be attributed to ignorance of biological theory, but in most it is clear that it is the basic "story" of evolution and/or the general principle that divine special creation is not its driving force which causes the difficulty. The alternative conceptions held by many orthodox Christians, seen today as nonscientific beliefs, were widely held in the past by impeccably educated and highly intelligent professional scientists (Mayr, 1982; Rudwick, 1976). With orthodox Christian students, therefore, an instructional focus on the accumulated facts (geological as well as biological) which historically led to the acceptance of evolution as a general notion is probably much more appropriate than a rigorous treatment of Darwinian theory.

By giving the participants in this study a voice in a science education forum, we hope that we have also demonstrated that, from a student's point of view, insensitive teaching about evolution also has the real potential not merely to fail but to do serious harm. Science educators must try to understand orthodox Christians' beliefs on their own terms, as representing a different set of values and concerns, which they see as justified in their own way for valid psychological reasons. As Moyer (1986) pointed out,

...most of all, [special creation] is a symbol for the deep concerns people have about their children: fear that the good life is about over; that society has become self-indulgent and immoral; that science is going too far, forcing wrenching decisions on people unprepared to make them. (p. 50)

The positive, pragmatic, enabling function of religion has been recognized and conceded even by the evolutionary theorist who is most often vilified in orthodox religious literature because he has long advocated the application of reductionist, determinist, materialist theory to psychology and the study of social institutions, as well as to explaining the physical attributes of
living things. Wilson (1978) sees religious belief as a beneficial adaptation preserved by natural selection, as indicated in this quotation from an interview:

The highest forms of religious practice, when examined more closely, can be seen to confer biological advantage. . . . In the midst of the chaotic and potentially disorienting experiences each person undergoes daily, religion classifies him, provides unquestioned membership in a group claiming great powers, and by this means gives him a driving purpose in life compatible with self-interest. (Wright, 1988, p. 196)

But such reasoning is irrelevant, if not nonsensical, to the participants whose words we have cited. Orthodox Christianity must be understood as a religious phenomenon and therefore as a legitimate concern of many people, including some scientists and science educators and many science students. It is "not 'nothing but' the voice of the hopelessly poor, deluded, or power-mad; the refuge of those who cannot live with ambiguity or paradox; the haven for the fearful and fanatical" (Marty, 1992, p. A56). For many people, it also serves an undeniable positive purpose, and for some others it need not serve as so much of an intellectual straitjacket as many science educators may think. Such a limited view is as much a misleading caricature as what evolutionists call the "nothing but" fallacy of human nature (Simpson, 1949, p. 283), which vilifies evolutionary theory for painting humankind as "nothing but another animal." Biology educators argue that a deep understanding of biology requires a focus on evolution as ultimate cause of the more immediately visible life processes, or proximate causes (Cummins & Remsen, 1992). In parallel fashion, many orthodox Christians' version of intellectual integrity requires them to seek causes beyond what scientists see as "ultimate." Geology and biology are necessarily silent on most of the questions dealt with by Scripture and other religious literature (Gould, 1991b). Science is not a myth, argued another evolutionary biologist, using "myth" not in its pejorative sense but rather to mean "a story with a moral message" (Maynard Smith, 1984, p. 11). It is to the extent that science is viewed as "limiting young people in their search for meanings of their human existence" (Moyer, 1986, p. 50) that science teachers will encounter legitimate opposition from people with a religious perspective.

If we are to make any progress in maintaining a dialogue between people of good will with such different assumptions about life, then we must move away from the mindset of teaching evolution as "a battle for people's minds" (Grobman & Grobman, 1989). Scientists and science teachers cannot continue to see themselves as righteous crusaders, participating in an epic struggle to eradicate mystical superstition and hasten the irresistible ascendancy of materialistic naturalism. "Science does not think," Heidegger said (Weizsäcker, 1980, p. 233), meaning that, ironically, the typical scientist (or science teacher) does not examine his or her own assumptions before summarily dismissing the conclusions of others with whom she or he disagrees. Science itself rests on a set of basic articles of faith, albeit very different ones from those of most religious traditions. As Wittgenstein said, "Doubting and non-doubting behavior. There is a first only if there is a second" (Weizsäcker, 1980, p. 37).

If science teachers are to turn their instruction about evolution into persuasion rather than propaganda or coercion (cf. Koballa, 1992), then they must avoid becoming like their intellectual enemies. Borrowing an insight from the multicultural education literature, originally developed in the context of problems created by racial differences, we should recognize the probability that many orthodox Christian students are not failing to learn, in the strictest sense, but rather actively and consciously "not learning" (Kohl, 1992). They may be closed-minded toward evolution as a subject because they have developed a quiet but strong personal hostility towards a teacher who does not make an effort to understand their personal background, values, and
motivations. Science teachers should not, of course, pretend that they have no differences of opinion with their orthodox Christian students, but they should cultivate a vision of a classroom that is an emotionally less traumatic place to be:

But this exchange takes place in a friendly atmosphere, and the religious faith of students is not ridiculed... One intangible item that can never be measured is the level of rapport between students and teacher. Some teachers can handle a controversial topic with aplomb, there as other instructors, regardless of their professional preparation, mismanage such situations. After several embarrassing incidents the latter tend studiously to avoid anything that would cause dissension. (Ellis, 1986, p. 80)

Classroom presentations and discussions about evolution, if informed by the twin perspectives of multiculturalism and a broadly conceived conceptual change theory, would be very different from the crusading, confrontational style frequently practiced and sometimes advocated.

A few people may believe that they have succeeded in subjugating any religious feeling in the name of science, and pride themselves on interpreting the world through their utterly rational mind, rather than their emotional "heart." Even for these rare individuals, however, these distinctions can break down in unguarded moments. Wright (1988), whose work served substantially as a methodological and stylistic model for this study, recounts a very revealing anecdote about the power and tenacity of southern U. S. religious culture in the face of decades of practice as a thoroughly secular scientist:

Like E. O. Wilson, I was brought up a southern Baptist. Like him, I encountered the theory of evolution as a teenager. Like him, I was bowled over by its power and beauty. Like his religious faith, mine did not survive this encounter with science in good shape.

But there is one difference between Wilson and me. He seems to have had no trouble filling the void. I, in contrast, regularly get wistful about the days when the question of purpose was settled once and for all, when I knew for certain why I was here and how I was supposed to behave.

Still, a funny thing happened a couple of years ago. Harvard was honoring Martin Luther King, Sr., and Reverend King, as part of the festivities, was preaching at the Harvard Memorial Chapel. Wilson, being a southerner, was invited to the service. There was a large turnout. The reverend preached fervently, and the congregation sang richly, and one of the hymns hit home with Wilson—"one of the good, old-timey ones that I hadn't heard since I was a kid." Partway through it, E. O. Wilson—scientific materialist, detached empiricist, confirmed Darwinian—started crying.

As if in atonement, he has a perfectly rational explanation. "It was tribal," he says. "It was the feeling that I had been a long way away from the tribe." (Wright, 1988, pp. 191–192)

Attachments, formed early in life and in one's native culture, to positive emotional (and, if you will, spiritual) touchstones are overwhelmingly powerful. They will almost always remain for life, regardless of quantity and quality of education or of duration and distance of separation from that culture, and perhaps this is especially true for natives of the southern United States. In the context of an incisive commentary on emancipatory curriculum theory, a leading Southern historian of education has noted that the failure to respect the integrity of regional culture is a prescription for practical failure. Theoretical critiques from people outside of this culture, while they may be internally consistent, are

... a fundamental denial of the conservative character of the southern experience and the critical alternative that experience has offered to mainstream industrial America...
Southern religion . . . is depicted as something to be worked through or overcome. . . . My own view is that the antidote . . . runs the risk of simultaneously curing and killing the patient. Is this not the ultimate irony? (Urban, 1992, pp. 437, 440)

Conclusion

The range of views of the people participating in this study may serve to illustrate why it is so difficult to make wholesale changes in thought and feeling regarding biological evolution and orthodox Christianity. The particular example of Ms. H illustrates that, even for an established professional in science education, seriously confronting the issue of the conflict between science and religion can have an effect that is enlightening but also greatly distressing.

We believe, however, that our experiences suggest a few rays of hope. An expanded personal dialogue between people from two such largely separate worlds can lead to greater mutual respect and understanding in both the personal and intellectual realms. Nobody was converted to a radically different set of beliefs or values, despite the fact that the first and third authors, in particular, began the study with a strong desire to serve as persuasive witnesses for opposite worldviews. What did occur in the case of several of the participants was a real change in attitude. For Dr. I and Dr. J, for instance, the combination of an ongoing intellectual clash and a growing personal friendship disabused them of several stereotypical notions about individuals from an unfamiliar cultural background. Ms. G, in contrast to so many other orthodox Christian students, was able to open her mind to a serious consideration of scientific account of the history of the earth and of life by adopting an approach to learning which recognized and accommodated the central importance of religion in her life.

There is certainly no foolproof strategy for encouraging orthodox Christian students to at least come to understand evolution (if not believe it), by building some meaningful bridge between their particular brand of prior knowledge and the world view of modern science. As one of the other participants said in summary, “There’s no universal bridge, just a bunch of individual bridges, and it takes a teacher sensitive to individual students to even have a prayer of accomplishing anything.” In short, we must concentrate our efforts on using our insight into students’ hearts to engage their minds, and not on a probably futile and possibly damaging attempt to change their hearts instead.

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Notes

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1 We originally sought out self-described “fundamentalists.” In the course of the study it became evident that the religious views of several of the participants were not fully fundamentalist in the restricted sense of the term, of which Biblical literalism is commonly considered an indispensable component. Several others who accept the descriptions “born-again” and/or “evangelical” prefer to be characterized as “orthodox” Christians rather than fundamentalists. The term “orthodox” (beginning with a lower-case letter) is therefore consistently used as a general descriptor in this paper, and does not refer to any of the specific sects collectively referred to by Western culture as “Eastern Orthodox.”

2 In all quotations from discussions and interviews, names used are pseudonyms.


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