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UMI
AN ANALYSIS OF FACTORS INFLUENCING THE TEACHING OF EVOLUTION AND CREATION BY ARIZONA HIGH SCHOOL BIOLOGY TEACHERS

by

Susan Jorstad

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A Dissertation Submitted to the Faculty of the DEPARTMENT OF ANTHROPOLOGY In Partial Fulfillment of the Requirements for the Degree of DOCTOR OF PHILOSOPHY in the Graduate College of THE UNIVERSITY OF ARIZONA

2002
As members of the Final Examination Committee, we certify that we have read the dissertation prepared by Susan Jorstad entitled "An Analysis of Factors Influencing the Teaching of Evolution and Creation by Arizona High School Biology Teachers" and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy.

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I hereby certify that I have read this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

Dissertation Director
Michael Schiffer

Date 4/19/02
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ABSTRACT

This study examined the amount of emphasis given by Arizona high school biology teachers to the topics of evolutionary theory and special creation, as explanations for the origin and diversity of life on earth. A questionnaire was mailed to all Arizona public high school biology teachers in March of 2000, to gather data on teachers' classroom practices and attitudes towards evolution and creation, information on teachers' educational and professional backgrounds, their religious preferences, and any perceptions of pressure regarding the teaching of evolution or creation from outside sources.

Sixty-five percent (final n = 419) of the questionnaires were returned. Analysis confirmed that, while a strong majority (96%) of Arizona teachers gave some coverage to evolutionary theory, a significant proportion (33%) reported fewer than three class periods per semester in which evolution was a major topic; 10% left it out entirely.

Fourteen percent of the teachers reported that they gave moderate-to-strong emphasis to religious explanations of the origins and diversity of life. It was unclear whether this was presented as an alternative scientific theory, or as religion or philosophy. Between ten and thirty percent also rejected the scientific validity of evolutionary theory, rejected the evolution of humans from ape-like ancestors, thought that religious explanations should be taught as part of high school biology classes, or agreed that creationism has a valid scientific foundation.

The amount of emphasis given evolution by a teacher correlated positively with teaching experience, number of college classes in evolutionary biology taken by the
teacher, the amount of in-service training a teacher had had on teaching evolutionary theory, and age. It correlated negatively with membership in Conservative Christian religious denominations and with degree of religious fervor. Interestingly, the possession of a degree in biological sciences (e.g., versus a degree in education) had no effect. When teacher attitudes (as measured by a series of opinion questions) were taken into account in multiple regression models, all variables except specific evolutionary biology coursework became non-significant.

The only variables that correlated with teacher emphasis on creationism were Conservative Christian church membership and religious fervor—both positive correlations. Again, education had no effect.
CHAPTER ONE
INTRODUCTION

Life in 21st century America is inextricably interwoven with the products of science and technology; we literally could not survive without them. We all use dozens of machines everyday, to prepare our food, to control the temperature and humidity of the spaces we occupy, to propel ourselves to work and school, and to help us do our work once we arrive. We rely on the science and chemistry of agriculture and animal husbandry for our ample and varied food supply, as well as on elaborate systems of safe food processing and rapid, economical distribution over vast distances. We live much longer and healthier lives than even recent generations due to astonishing advances in medical science, including drugs, surgical techniques, diagnostic tools, and even artificial replacement parts. Infectious diseases that, just a generation ago, killed untold thousands every year have been eradicated, and we have severely reduced the impacts of many other such diseases. Scientists are on the verge of being able to cure previously incurable genetic and degenerative diseases through advances in gene technologies and stem cell research. We now have the capability of traveling to outer space, to the bottom of the ocean, or around the world in a matter of hours. We have contact with nearly every corner of the globe via telephone and satellite; information and entertainment stream into our homes and offices through cable, phone, and fiber optic lines.

An understanding of science is then of critical importance for all American citizens. Over two hundred years ago, our nation's founders recognized the inestimable
value of a well-educated citizenry, as Thomas Jefferson called for "...the diffusion of knowledge among the people. No other sure foundation can be devised for the preservation of freedom and happiness" (Jefferson 1786). Those concerns are echoed today by the National Academy of Sciences: "the fortunes of a nation rest on the ability of its citizens to understand and use information about the world around them" (NAS 1998:viii).

American citizens, then, eagerly embrace the products of scientific research, and enthusiastically support the process of science as a way of generating information about the natural world. They also, therefore, insist upon the highest standards of science education for their children, recognizing that scientific literacy is critical, not only for the success of their children, but for the future of the country. Or, do they?

Actually, it seems that they do not. The United States regularly fares very poorly in international performance tests in science and mathematics achievement for students, placing fourteenth out of seventeen nations in 1988 (Walsh 1988), and more recently below the international mean, behind Bulgaria, the Czech Republic, Singapore, and Taiwan, among others (Holden 2000). Not surprisingly, the general public also demonstrates a low level of science literacy (Miller 1987), with 21% thinking that the sun orbits the earth, and half of the public believing that 'God created man pretty much in his present form at one time within the last 10,000 years' (Gallup 1991). This apparent ignorance (or rejection) of well-established scientific findings calls into serious question the ability of average citizens to participate in the democratic decision-making process on any issue of science policy (Langenberg 1991; Toumey 1996). It also casts doubt on the
ability of the average citizen to make an informed contribution if seated on a jury trying
one of the myriad legal cases involving elements of scientific or medical proof, such as DNA evidence. In an age in which everyday life is increasingly dependent upon science and technology, it is correspondingly increasingly important that citizens be able to understand and use that science and technology; it is through education that citizens achieve that ability. So, why is American science education falling short?

The low level of performance by American students is often attributed to a lack of funding for education in general, the absence of adequate educational standards, and poor teacher preparation (all of which can be viewed as forms of apathy), and these are certainly serious concerns. However, there are other powerful social forces at work in generating the American public's ambivalent relationship with science and science education. Indeed, it seems that a significant segment of the American populace is downright hostile towards science, particularly when its findings conflict with religious doctrine.

Specifically, Christian religious fundamentalists have been attempting for the better part of the last century to remove the teaching of evolutionary theory from public school science classrooms, and continue to do so today. While creationists are by no means monolithic in their views, they are united by the belief that a supernatural entity created the universe and humankind, and the belief that evolutionary theory is the root of godlessness and immorality in contemporary society (Tourney 1994). These anti-evolutionists, or creationists, prefer, instead, that the biblical account of the origin of life on earth be taught in public schools—no Big Bang, no descent with modification for all
life forms, and certainly no common ancestor for modern apes and humans. Modern creationists do not make these claims by rejecting all of science, nor the epistemological foundations of science, but instead by putting a distorted version of science to their own uses. That is, they endeavor to demonstrate the truth of their position by offering scientific-sounding data and theory in something called “scientific creationism” or “creation science” (Scott 1996). This form of religion-based anti-science has very deep historical roots; this is just the most recent manifestation of a centuries-long conflict between the knowledge generated through scientific inquiry and religious orthodoxy. It is, at the most basic level, a collision of worldviews—one that sees the betterment of human life through advances in science and technology, and another that views adherence to scripture as the only way to save mankind from the degenerate secularization of modern life (Brooke 1991; Numbers 1993).

While creationist attacks on science may seem to emanate from fringe groups with little hope of effecting real change, or even gaining much attention in wider society, such is not the case. Although creationists have thus far been legally thwarted both from outlawing the teaching of evolution in the public schools, and from legislating equal time devoted to the creationist account of the origin and diversity of life on earth, such efforts continue unabated. The National Center for Science Education reports currently pending anti-evolutionary legislation in ten states: Arkansas, Georgia, Hawaii, Indiana, Louisiana, Michigan, Montana, Pennsylvania, Washington, and West Virginia (Scott 2001).

More importantly, a non-legislative anti-evolutionist tack has met with much more success, as creationists position themselves on school boards where they can, and
do, effect changes in curriculum content, by minimizing or eliminating the topic of evolution from state performance testing standards and curriculum guidelines. A well-publicized example is the action taken by the Kansas State Board of Education in August of 1999 to drop evolution from statewide standards (Holden 1999). While the Board members responsible were replaced in subsequent elections, and evolution was eventually returned to the standards (Simon 2001), this was not an isolated incident: several other state boards of education (for example, Arizona and New Mexico in 1997) have revised biology curriculum guidelines (or standards) with the complete omission of theories of evolution, the age of the earth, and the 'Big Bang', (Rissing 1998). In both these cases, the furor raised by academics, religious leaders, and members of the public resulted in the re-institution of these topics into the curriculum before the changes were implemented. Concerning other non-legislative efforts, the National Center for Science Education (NCSE) reports that Alabama and Louisiana currently require disclaimers regarding evolutionary theory be placed in school biology textbooks; eight other states avoid discussions of evolution in biology classes, and a further 25 states have reported controversies over the teaching of evolution in the public schools (Christensen 1998; NCSE 1999). The latest creationist permutation, "intelligent design theory," is also being proposed for inclusions in several states, most recently in Ohio (Clines 2002). Prominent researchers view the anti-evolution movement as having significant impacts on future generations through public education, by successfully focusing their efforts on changing curricula at the K-12 level of the public schools nationwide (Greenwood & North 1999; Scott 1997).
Is this really a problem? Since it conflicts with the religious views of some Christians, is it really necessary that evolution be taught as part of public school biology classes? The answer to these questions is a resounding, yes! Evolutionary theory is said to be so central to the study of biology that "Nothing in biology makes sense except in light of evolution" (Dobzhansky 1973:125). The scientific and educational communities have been forceful in their endorsement of the central role of evolutionary theory in the biological sciences: the American Association for the Advancement of Science (AAAS 1993), the Biological Sciences Curriculum Study (BSCS 1993), the National Academy of Sciences (NAS1998, 1999), the National Research Council (NRC1996), and the National Science Teachers Association (NSTA 1996) have all strongly urged the teaching of evolution.

An understanding of basic biological processes enables an educated populace to understand the care and feeding of the human body, the action and evolution of pathogens, and the balances necessary to maintain healthy ecosystems, so that they may make intelligent decisions about themselves, their families, and their world. It is virtually undisputed that one of the central organizing principles of biology, evolutionary theory, is a cornerstone of such an education.

However, resistance to evolutionary theory and confusion about the nature of science are surprisingly widespread, extending well beyond the population of religious fundamentalists. The eminent paleontologist George Gaylord Simpson had these thoughts on the subject:

Suppose that the most fundamental and general principle of a science had been known for over a century and had long since become a main
basis for understanding and research by scientists in that field. You would surely assume that the principle would be taken as a matter of course by everyone with even a nodding acquaintance with the sciences. It would obviously be taught everywhere as basic to the science at any level of education. If you think that about biology, however, you are wrong. Although almost everyone has heard of it, most Americans have only the scantest and most distorted idea of its real nature and significance. I know of no poll but I suspect that a majority doubt, disbelieve, or violently oppose its clear truth without a hearing and on no basis more rational than prejudice, dogma, or superstition. Many school and not a few college teachers either share that irrationality or evade the truth of evolution from other motives (Simpson 1963: 26).

Lest we think either that Simpson's suspicions were unfounded, or that the situation has changed since the early 1960s, recent national polls have consistently shown that a majority of Americans is uncomfortable with the theory of evolution (Gallup & Bezilla 1994; Recer 1996), and that although a strong majority (83%) believe evolutionary theory should be taught in public school science classes, nearly 30% also believe that creationism should be taught as science—16% asserting that creation alone should be taught as science (PFAW 2000). Republican Party platforms in several states advocate the teaching of creationism, and education officials in several states openly defy recent Supreme Court decisions by encouraging teachers to teach creationism (Moore 2000b). The current House Republican whip, Tom Delay, publicly blames societal ills such as school violence, birth control, and abortion on the teaching of evolutionary theory in the schools (NY Times 1999).

While religious fundamentalism may explain much of the support for creationism in the schools—about 10% of Americans describe themselves as fundamentalists, and 30% believe that the Bible to be the inerrant word of God (Davis et al. 1998)—it does not
account for the more widespread discomfort with evolution among non-fundamentalists.

Additionally, while the biblical literalist minority of the American public has not yet been successful in permanently changing the content of public school classrooms, survey after survey demonstrate that the central organizing theory of biology is being de-emphasized, or omitted in biology classrooms across the country (Aguillard 1998; Miller 1990; Osif 1997; Weld & McNew 1999). Who or what is responsible for this serious shortcoming in American science education?

Because teachers have a great deal of leeway in determining the content of the materials and topics presented in their classrooms, we might legitimately be concerned with the impact on biology teachers of the court cases, the attempted (and successful) curriculum changes, and the attendant publicity surrounding the evolution/creation debate. Do teachers feel pressured by parents, students, or other community members to downplay or omit evolution, or (perhaps the greatest danger to evolution education) do they do so out of fear of arousing controversy (Scott 1997)?

High school biology teachers in particular are the logical focus for the study of the impacts of social and religious forces on the teaching of evolutionary theory. For the vast majority of Americans, such teachers are the sole source of information on this topic. Most people in the United States have only one introduction to biology, usually in the ninth or tenth grade; most will not go on to college (USDC 1999), and those that do, will, in most cases, not take another biology course (USDE 2000).

The present study seeks to explain a particular deficiency in American science education: the fact that many students receive little or no exposure to the central
explanatory framework of modern biology, evolutionary theory. High school biology teachers have a great deal of autonomy within the confines of their classrooms to emphasize, de-emphasize, or eliminate any topic in the textbooks they use. How they are responding, both to external pressures from their communities and to internal motivations is therefore of interest to anyone concerned with the current state of science education in America. How do high school biology teachers make their decisions regarding the teaching of evolution? The present study measures the level of emphasis given evolution and creation by Arizona high school biology teachers, as well as their attitudes towards the teaching of those same topics.

High school biology teachers no doubt share to varying degrees the cultural values of their compatriots, including religious fundamentalism. Is the level of religious fundamentalism in the population of high school biology teachers similar to that in the general public? Does an education in the biological sciences (and therefore, presumably, a higher level of science literacy than that achieved by the average citizen) have any effect on a teacher's acceptance of evolutionary theory and willingness to teach it? If not, are there other social or demographic factors, or combinations of factors, that influence a teacher's behavior and attitudes toward the teaching of evolution?

The aim of the present study is to address these questions, to offer a better understanding of some of the complex social issues impacting science literacy in the United States, and to offer some possible solutions, both in teacher preparation and teacher-student interaction regarding the topic of evolutionary theory, where science and religion seem to collide.
The remaining chapters of this dissertation are organized as follows. Chapter Two traces the history of science and religion in conflict and accommodation, with special attention to the impacts of Darwin's theory of evolution by natural selection in the 19th and 20th centuries. Subsequent chapters trace the evolution of American Christian Fundamentalism and its role in modern antievolutionism (Chapter Three), and the effects of those forces on the practices of biology teachers as measured by surveys over the past sixty years (Chapter Four). Finally, the methods and results of the present study, measuring the attitudes and behaviors of Arizona high school biology teachers in 2000 are presented (Chapters Five and Six), ending with Chapter Seven, in which the results are summarized and discussed, and some recommendation offered on how teacher education might be modified to improve the teaching of evolution.
CHAPTER TWO

A History of Science and Religion in Conflict

It has been said that the two pre-eminent impacts on the ascent of Western Civilization have been the rise of Christianity and the Scientific Revolution (Brooke 1991). Each has played an important role in shaping the values that define Western society, but the interactions between them have been variously complementary and contentious, often spiced by the high stakes of political power, social prestige, and intellectual authority (Ferngren et al. 2000).

The relationship between science and religion has certainly varied through time, and there is not even any real consensus of what the relationship should be. Broadly speaking, it can, however, be characterized in one of three different ways: a conflict model in which a reality based on testable facts is in direct opposition to one reliant on faith and revelation; a separationist model in which it is viewed that science and theology address entirely separate, independent, and but equally valid spheres of human need and practice; and a mutualism model in which each realm benefits from interaction with the other, as moral and ethical concerns inform scientific research, and certain religious beliefs and practices may be conducive to scientific investigation (Brooke 1991; Kurtz 1996; Scott 1996; Wilson 2000).

The focus of the current study is on one area of current conflict between science and religion: the impact of groups and individuals who reject the findings of science with regard to the origin and diversity of life on earth (i.e., evolutionary theory), which are seen to be in conflict with their literal interpretation of Genesis in the Old Testament of
the Christian Bible, as well as the broader appeal of these creationist views to non-literalists. It specifically addresses the impacts of this social phenomenon on teachers of high school biology, whose job it is to develop science literacy in American young people. As is detailed in Chapter Four, a significant proportion of high school biology teachers nationwide de-emphasizes or completely omits a discussion of the principal organizing framework of their discipline. This serious shortcoming in American science education demands examination and explanation. It is my thesis that shortcomings in the educational preparation of teachers, plus real or apparent conflicts between religious and scientific worldviews are the prime causes of this phenomenon.

The history of the conflict between science and religion is almost as long as the history of science itself (see relevant discussions in Brooke 1991; Dampier 1971; and McClelland & Dorn 1999). In almost all cases, it has grown out of a conflict between emerging scientific knowledge and the prevailing worldview, which in turn had its roots in Christian religious doctrine. As science continues to expose, unravel and explicate the natural mysteries of life, the role of religion in explaining these mysteries is diminished. Thus, the conflict is over which realm, science or religion, has explanatory primacy. We must begin, however, centuries before the birth of Christ, with Aristotle, whose studies encompassed logic, physics, cosmology, psychology, natural history, anatomy, metaphysics, ethics, and aesthetics, and who is credited with laying the foundations of modern scientific methodology (Sarton 1993).
Early Natural Philosophers and Natural Historians

We begin with Aristotle because, although his writings dominated scientific traditions for 2,000 years, his ideas were not seen as in conflict with the religious establishment, either in his time or in later centuries (Grant 2000). He proposed a common-sense view that nature would be revealed by deduction from self-evident premises, and saw sensation, everyday experience and commonsense observation as the valid routes to knowledge. At the core of this was a belief in a divine cosmos, orderly and static, set in motion by a Prime Mover—ideas quite compatible with the theologies of Judaism, Christianity, and Islam in the centuries to come (McMullin 1998). By the 13th century, however, some discord had been noted, as Roger Bacon, father of the inductive method based on observation and experimentation, was arrested for heresy and imprisoned for much of his life by Pope Nicholas IV when he challenged the church-sanctioned Aristotelian view of the world as static and human-centered (Dampier 1971).

The first serious conflicts between science and religion began with the 16th century work of Copernicus, which helped to launch the Scientific Revolution and initiated the modern scientific worldview by proposing, with mathematical supports, a heliocentric cosmology at a time when the rest of the world placed the earth at the center of the universe (McClelland & Dorn 1999). Although Copernicus himself was able to stave off religious backlash to his theory of heliocentrism in his lifetime, others who espoused and furthered his ideas were not so fortunate. The astronomer Johannes Kepler was driven from his position in Graz, Austria, in 1600 for advocating Copernicus' theory in defiance of the Catholic church. Galileo's suffering and imprisonment at the hands of
the Inquisition, where he was charged with heresy and threatened with torture until he recanted Copernican theory, and his quite recent pardon, are also well-documented (Blackwell 2000; Finocchiaro 1989). In each of these cases, the scientists were seen as enemies of orthodoxy, because they took the philosophical position that when revealed wisdom (theology) and scientific findings appear to be in contradiction, it is science that supercedes theology in questions concerning nature. Galileo, in particular, viewed the Bible as having been written to be understood by the common people, and therefore open to reinterpretation, whereas he saw nature as possessing an unalterable reality (Finocchiaro 1989).

While Galileo suffered the consequences of giving scientific knowledge primacy over religious doctrine, most scientists of his and later times experienced no such conflict. Well into the 19th century, Newton’s 18th century “natural theology” was the reigning scientific philosophy, presenting faith and reason as two faces of the same coin: the Bible as the Word of God, and nature as the Work of God. Examined properly, it was believed, each told the same story. The smooth, clock-like workings of the universe proved that there was a Watchmaker or Designer, and the job of scientists was to reveal the beauty of God’s Work by studying and illuminating the mechanisms (Brooke 2000; White 2001). This is not surprising since many scientists of the time were, in fact, men of the cloth, educated in sacred institutions of learning.

Likewise, most theologies attempted to accommodate new scientific knowledge, by taking an ever more liberal (and less literal) interpretation of the truths in the Bible (Brooke 1991). As long as the Bible was not viewed as inerrant, in details of history or
natural history, there was no real conflict. To the contrary, the notion that the study of
nature was an act of piety actually strengthened the concordance between science and
religion, while at the same time, science offered a new worldview of progress through
knowledge of the workings of the natural world (McClelland & Dorn 1999).

Newton's work also had an important social application, as he is said to be the
founding father of the Enlightenment, the social movement which embraced the notions
of social progress and human perfectibility (Broman 2000). Newton endeavored to
replace superstition and irrationality with reason: "In reason's light, the clouds of
ignorance/ Dispelled at last by science" (Edmund Halley 1687, preface to Newton's
Principia). Newtonian science and Newtonian Enlightenment are likewise seen by some
to be the modern, liberal, progressive, reformist, and revolutionary ideals behind the
American and French Revolutions of the late 18th century (McClelland & Dorn 1999).
As we shall see, it is partially in reaction against this "modernism" that powerful anti-
evolution forces would arise in the 20th century.

**Charles Darwin and Evolutionary Theory**

This was the state of the world when Charles Darwin (with Alfred Wallace)
stepped onto the stage in 1859, revolutionized the science of biology, and unwillingly
ignited a science-religion conflict that continues unabated today. At the time, most of the
world, including scientists, viewed the earth and its inhabitants to be perhaps 6,000 years
old; most believed that a deity had created living things in the forms in which they
existed in the present. The prevailing view amongst natural historians was the common-
sense conclusion that each species, or natural kind, was fixed, unchanged and unchanging over time.

These assumptions had been questioned by some scientists for quite some time, however. In 1795, James Hutton had suggested that uniform physical processes were responsible for modern geological features (Hutton 1795), seemingly contradicting the notions of stasis and divine design. Building on those ideas, geologist Charles Lyell rocked the scientific world in 1830 when he proposed, based on these same uniformitarian principles, that the earth was quite old, perhaps millions of years old, as geological processes visibly and measurably at work in the present would need vast spans of time to create the mountains, canyons, and deep stratigraphy comprising the modern landscape (Lyell 1830-1833). Christian geologists of the time were able to reconcile these new scientific ideas with traditional religious beliefs by reinterpreting the “days” of Genesis as geological ages, or alternatively, by positing long gaps in the Genesis account (Larson 1997). These accommodations were accepted by most 19th century Protestants, and define modern-day “Day/Age” and “Gap” creationist ideologies (Scott 1997).

Various natural historians had also begun to question how organisms had come to be as they are, beyond the biblical explanation, and the ever-mounting evidence from paleontology and comparative anatomy seemed to some to document change through time in hundreds of life forms, contrary to the well-established dogma of stasis and the fixity of species (Buffon 1792; E. Darwin 1796; Lamarck 1809). What was lacking, and what Charles Darwin and Alfred Wallace provided, was a plausible mechanism by which such change through time, or evolution, could be effected—a gradual, natural, law-bound
process that Darwin called ‘descent with modification via natural selection’ (Darwin 1856). This theory proposes that random biological variation amongst individuals exists and is heritable, and that interaction with the environment determines the extent to which any given variation will be represented in subsequent generations. That is, those individuals with advantageous traits survive longer and produce more offspring, which will have inherited those favorable traits. Thus, favorable variants become more common through time, unfavorable variants are eliminated, and the nature of the population changes, leading in some cases to the formation of new species. This theory had an explanatory power that organized and made coherent the myriad observations of many other scientists in paleontology, comparative anatomy, and embryology, among others.

Although the proposition that evolutionary change in living things was part of the natural history of the earth was by no means a new one, dating back at least to Greek and Roman thought (Ruse 1999 and references therein), the publication of Darwin’s ideas elicited an unprecedented response, for their implications beyond biology were immediately apparent. The replacement of the conventional ideas of recent creation and stasis by the newly plausible ideas of vast time spans and change threatened the established social order. If nature, without a Designer, could produce the extraordinary complexity of human beings in a natural, law-like way, and man therefore does not differ from lowly animals, why should people be expected to behave differently from beasts of the jungle? The “twin philosophical implications of Darwinism,” the concepts of unlimited change, and metaphysical purposelessness, were thus deeply troubling to a conservative Victorian-age world ( Nelkin 1982:27). To traditional Christians, who
embraced a teleological view of nature, the randomness of variation and the heartlessness of adaptation through natural selection ("survival of the fittest," as it would later be characterized) were particularly troubling (Larson 1997). A loving, purposeful Creator was a much more comforting image than blind, uncaring natural forces, deaf to the desires of man.

**Anti-evolution in the 19th Century**

Initially, the strongest reaction to evolutionary theory was from the traditional scientific community, whose theoretical foundation, still deeply intertwined with religious dogma, was shaken: the philosophy of natural theology construed the role of scientists to be the discovery of the ultimate design and purpose of divine creation, and Darwin’s theory left no specific role for a creator (McClelland & Dorn 1999; Nelkin 1982). There was also resistance to the deductive nature (i.e., from the general to the specific) of Darwin’s work, since the contemporary view of science was one of Baconian/Newtonian classified knowledge, which dictated the theory-free inductive gathering of facts leading eventually to generalization—not the other way around (Larson 1997; Nelkin 1982). Additionally, Darwin had no plausible mechanism for sources of variation or the processes of heredity, and waffled unconvincingly between several models (e.g., the idea of "gemmules," and Lamarckian inheritance), having of course, no notion of modern genetics; in fact, these issues would not be resolved for many decades (Ruse 1999).

Despite these problems, most scientists soon came to accommodate Darwin’s theory in one way or another. By 1880, the scientific community in the United States had
largely accepted Darwin's theory of organic evolution; proponents of special creation at the time could name only two working naturalists in North America who opposed evolution, John William Dawson of Montreal and geographer Arnold Guyot at Princeton (Numbers 2000). Even the highly religious scientist (e.g., the evangelical Protestant and Harvard botanist Asa Gray, and the well-published naturalist Joseph LeConte) found a role for God, for example, in the generating or directing of variation (Gray 1880; LeConte 1891). Genetics studies in the 1920s would weaken this position, however, once again shrinking the buffer zone of accommodation between religion and science.

Even where it was to be found, the level of disagreement between evolutionists and academic anti-evolutionists in the 19th century was actually fairly low. Avowed atheists were a tiny minority of scientists, so for the vast majority of natural historians and natural philosophers, the rub came in defining a role for a divine creator: theists required a God who created and continues to interact with and direct life on earth, while deists specified a God who created and then stepped back to allow things take their course (McIver 1989). "To find a creationist [of the 19th century] who insisted on the recent appearance of all living things in six literal days, who doubted the evidence of progression in the fossil record, and who attributed geological significance to the biblical deluge, one has to look far beyond the mainstream of scientific thought" (Numbers 1993: 11). This is significant, since all of the aforementioned elements would come to characterize the beliefs of the most vocal faction of modern 21st century anti-evolutionists.
By the end of the 19th century, evolutionary theory had been well-integrated into American education, serving as the organizing principle for zoology courses recommended by the National Education Association, and appearing regularly in high school and college textbooks (Nelkin 1982).

While the scientific community fairly quickly, although not unanimously, accepted evolutionary theory in Britain (Ruse 1999) and in the United States (Numbers 1993) within twenty years of the publication of *On the Origin of Species*, the response of the religious establishment to Darwin’s ideas was markedly diverse, even within the same religious denomination (Brooke 1991). This reflects to some extent historical particularities of the time, both theological and social. In the mid-19th century, serious conflicts had arisen within and between Christian denominations. Traditional theologians denounced advocates of a less dogmatic and less conservative Christianity—so-called “modernism” in the Protestant faith. This form of modernism itself comes out of the French and German biblical “higher criticism” and evolutionary worldview of the 19th century, in which literary analyses of the Bible focused on the historical and cultural context of scripture, and supernatural events like miracles and prophesy were denied; additionally, Christianity was seen as the natural social evolution of the Hebrew people (Hart 2000; Larson 1997).

This liberal philosophy would come to dominate the major Protestant denominations, but, of course, was considered heresy by traditionalists, and a major rupture in Protestant theology resulted. On the one hand were those liberals who viewed biblical truths as figurative; on the other were those conservatives who held that only an
inerrant Scripture was authoritative (Hart 2000). The new biblical “higher criticism” joined with the new uniformitarian geology and the new evolutionary biology to undermine traditional Christian belief in special creation and the reliability of Genesis in matters of human origins. Thus, the issue of biological evolution was just one battle in a much larger war. So, while conservative theologians and biblical literalists found the absence of God and atheism at the root of evolutionary theory, the majority of contemporary religious thinkers were happy to accept organic evolution as God’s method of creation—the philosophy of theistic evolution (Brooke 1991; Ruse 1999).

Religious traditionalists, however, reacted against Darwin’s ideas from the pulpit and in public debates, characterizing evolutionary theory as attempt to ‘dethrone’ God, or even as overtly atheistic (Moore 1979), and clearly aware of the implications to society of such a view. Following the chaos of the French and American Revolutions, the church and religion were considered by many to be “the essential theoretical and social underpinnings for the order and stability of society” to the extent that “attacks on the church and religion were seen not only as blasphemous and immoral, but as socially dangerous” (Ruse 1999: 17).

Darwin’s work was viewed as just such an attack, impinging upon and contradicting the religious truth of the book of Genesis. It appeared to challenge many aspects of popular Christian doctrine: the nature of biblical authority, the historical nature of the creation story, the nature of God’s activity in the world, the belief that humans were made in God’s image, the meanings of original sin and redemption, and the ultimate
foundation of moral values, among others (Brooke 1991). This, despite the fact that Darwin himself expressly credits a Creator:

There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one; and that... from so simple a beginning endless forms most beautiful and most wonderful have been and are being evolved (Darwin 1859: 450).

The intellectual ammunition used to combat evolution in the 19th century also varied considerably. Until around 1875, Protestant intellectuals had rejected Darwinian theory as unscientific, turning to the writings of Harvard zoologist Louis Agassiz for support for this position; after Agassiz’s death, when it became clear that the majority of naturalists embraced evolution, Protestant leaders turned to theological, rather than scientific arguments against the theory—i.e., that evolutionary theory was invalid because it conflicted with the message of the Scriptures (Roberts 1988).

Fears of the broader social implications of acceptance of evolutionary theory continued to be articulated: Moody Bible Institute lecturer Alexander Patterson predicted that “if this theory is accepted, we must look for widespread lapse from all Christian faith, and, as conduct follows belief in all intelligent creatures, we shall see also great moral declension” (Patterson 1906, cited in Roberts 1988: 96). Interestingly, like their scientific anti-evolutionary brethren, virtually none of the ecclesiastical critics contested the age of the earth or attempted to explain the fossil record in terms of the Noachian flood (Numbers 1993). As early as 1880, a contemporary religious weekly estimated that between one-quarter and one-half of educated Evangelical (conservative) ministers viewed the story of biblical creation to be a parable rather than literal truth (Ward 1880, cited in Numbers 1993). At this point in history, the problem with Darwinian theory for
religious conservatives was not so much a contradiction with a literal interpretation of Genesis; it was the absence of God in the origin of species, particularly in the origin of man that rankled.

**Anti-evolution in 20th Century America**

By the turn of the 20th century in America, mainstream science and mainstream theology had accepted evolutionary theory, and integrated it in various ways into their worldviews. A series of historically particular circumstances would disrupt this balance, to the extent that by the late 20th century, the teaching of evolution in public school science classes would be challenged in nearly every state. This greatest public challenge to Darwin's theory would come, not from scientists, nor from mainstream theologians, but from a new breed of religious fundamentalists, aided by serendipitous changes in American public education. Additionally, the particular form of creationism favored by many of these modern-day fundamentalists is a throw-back to a literal six-day sudden creation, a young earth, and Noachian flood geology—the most conservative of positions (Zetterberg 1983). How this extremist viewpoint came to dominate the evolution/creation debate is an interesting tale. As Protestant fundamentalist creationism constitutes the most widespread, most vocal, and most successful opposition to evolution in the United States today, a brief examination of its historical and philosophical underpinnings is in order—and provided in the following chapter.
CHAPTER THREE

Evangelicalism and Fundamentalism in America

George Marsden provides a thorough discussion of the evolution of Protestant evangelism and fundamentalism in America in his seminal work, *Fundamentalism and American Culture* (1980). For a painstaking analysis of historically-important fundamentalist and creationist texts, see Thomas McIver’s 1989 doctoral dissertation and an earlier annotated bibliography of creationist writings (McIver 1988, 1989). An encyclopedic edited volume on the history of science and religion (Femgren et al. 2000) is also an important resource. For a full discussion of the so-called “intelligent design movement,” I highly recommend a recent edited volume that includes arguments by both advocates of ID and their critics in science, philosophy, and theology (Pennock 2001).

Evangelical and fundamentalist Christians have been deeply involved in cultural and political contests over the role of science in society at least since the mid-eighteenth century. To clarify, the term ‘evangelical’ generally refers to a family of Protestant traditions arising out of the English Reformation, and embracing the core religious convictions of “conversionism, the belief that lives need to be changed; activism, the expression of the gospel in effort; biblicism, a particular regard for the Bible; and what may be called crucicentrism, a stress on the sacrifice of Christ on the cross” (Bebbington 1989: 2-3). Fundamentalism can be seen as a particularly militantly anti-modern American Protestant subset of evangelicalism, more sectarian, or even cultish, than denominational in nature (Marsden 1980). Core tenets include belief in biblical...
inerrancy; Christ's virgin birth, atonement and resurrection; and the authenticity of supernat}
al miracles (McIver 1989).

Fundamentalist creationism is thus also based on a belief in the absolute inerrancy of the Genesis account of creation; with fundamentalist claims to absolute Truth via the Bible, competing explanations, such as descent of living species from ancestral forms, are held to be both false and dangerous (Marsden 1980). Fundamentalists are deeply concerned with what they see as the degeneration of society, and have responded with a vigorous mixture of television and radio ministries, publishing networks, separate denominations and independent churches (Marsden 1980; Noll 2000).

Additionally, fundamentalists have a very different relationship with science than does mainstream Protestantism. Evangelicals, including fundamentalists, are seen as diverging from historic mainstream Christian attempts to reconcile revelations from scripture with emerging scientific knowledge, to the extent they sometimes promote anti-intellectual attitudes (Noll 2000), such as denying the great age of the earth, the efficacy of radiometric dating techniques, uniformitarian geological principles, and the constancy of the speed of light, among others (see creationist writers Whitcomb & Morris 1961; Morris 1986). Paradoxically, 18th and 19th century evangelicals in both Britain and the U.S. initially embraced science, attempted to exploit scientific findings, and adopted the language of science as their own in efforts to demonstrate the truthfulness of Christianity—e.g., appealing to universal standards of reason and science to combat what they saw as irreligion, radical democracy, and disorder on the frontier following the Revolutionary War (Noll 2000). In fact, the modern evangelical movement remains
committed to the same narrow inductivist Baconian-Newtonian ideals that first attracted their forebears, and this outmoded scientific approach characterizes modern "creation science"—i.e., the attempt to find scientific evidence to prove sudden creation and a young earth (McIver 1989).

**Theoretical/Theological Foundations of American Fundamentalism**

The primary historical/theoretical foundations of fundamentalism in America are seen as threefold: the doctrine of dispensational pre-millennialism, Protestant scholasticism (and the related Scottish Common Sense realism), and the aforementioned Baconian-Newtonian view of science (Marsden 1980).

From about the mid-18th century until the Civil War, the popular theological view in America was predominantly post-millenialist: the essentially optimistic belief that Christ would return to earth after the millennium, establishing God’s Kingdom on earth, demonstrating the triumph of Christianity, and affirming America as Zion. The 19th century saw a shift to a decidedly more pessimistic pre-millennialist view that the world was becoming less, not more, Christian; that evil was triumphing; that America was Babylon rather than Zion, and deaf to God’s word; and that the best that could be done was to save as many souls as possible from the Armageddon that was near at hand (McIver 1989). This belief remains at the core of some of the best-known modern creationist writings (e.g., Whitcomb & Morris 1961).

Another important fundamentalist foundation, the concept of Protestant scholasticism, was developed by the great Princeton theologians of the 19th century, and is strongly linked to Scottish Common Sense philosophy: the Bible is a set of plainly-
stated factual propositions, and is the sole and sufficient source of revelation; like facts of nature, facts of the Bible can be proven true, and laws can be derived; truths of the Bible are perspicuous and accessible to all readers; facts, both biblical and natural, are objective, discoverable, and immutable (Marsden 1980). Theology was viewed as a form of Baconian science—i.e., the taxonomical gathering and classifying of facts so that general principles emerge. What is also implicit is a doctrine of biblical inerrancy: God would provide nothing less than wholly accurate facts, whether large or small; thus, the facts of science cannot be true if they contradict the facts of the Bible. Another important conclusion from this dominant theological tradition of 19th century America was the notion that the fact that God had designed (created) the universe was self-evident, proving that evolution was utterly impossible (Marsden 1980).

The third main theoretical underpinning of fundamentalism and modern creationism, a Baconian-Newtonian view of the philosophy of science, is another part of the heritage of modern fundamentalists from the Princeton theologians. In this view, the main business of science is to argue from phenomena without ‘feigning’ hypotheses, and to deduce causes from effects “till we come to the very first Cause, which certainly is not mechanical…” but rather Divine design (Newton 1713: General Scholium of Principia, 2nd and subsequent editions; reprinted in Cohen & Whitman 1999: 943). Science is thus viewed by modern creationists as knowledge produced from “facts that have been observed and laws that have been demonstrated...It is not inference or speculation or extrapolation” (Morris 1968: 12). Darwin’s model could thus be criticized both as being...
insufficiently inductive, and as sullying simple common-sense observations with
'speculative' theory.

Coalescence of American Fundamentalism in the Early 20th Century

From these foundational elements (the idea that it was possible to reason one's
way to faith through the common-sense facts of the Bible and the common-sense facts of
nature, and a belief in the unchanging, factual inerrancy of the Bible) evolved a
philosophy of "Bible science," the notion that all of modern science is contained within
the Bible, which anticipates and predicts the discoveries and inventions of modern
science (Marsden 1980). Early 20th century Fundamentalism also benefited from the
spread of a new mass medium with the 1910-1915 publication of a series of widely
distributed pamphlets called The Fundamentals. These treatises set forth the core
principles of fundamentalist Christianity, attacking both "modernity" and evolutionary
theory, and a significant social movement began to crystallize (Nelkin 1982). Through
these pamphlets, thousands of average Americans were exposed for the first time to
Darwin's theory of evolution and the discomfiting theological conflicts it provoked.
America's response to this was, again, historically particular.

The coalition of a previously diffuse, inchoate, and geographically dispersed
fundamentalist movement around anti-modernism and anti-evolution coincided with two
other important historical factors: a ten-fold increase in enrollment in American public
high schools between 1890 and 1920 (Larson 1989, citing Krug 1969), and the shock of
World War I. Due to the increased high school enrollment, Darwin's theory (along with
many other scientific ideas, of course) found its way into many American homes for the first time: "evolution had reached the high schools and high schools had reached the people" (Hofstadter 1962: 126). Thousands of concerned parents found that their children were being taught things in biology classes that contradicted their religious views, and they raised the alarm, calling in the 1920s for the dismissal of any teacher who believed in evolution (McIver 1989). "As one rabble-rousing creationist put it, the German soldiers who killed Belgian and French children with poison candy were angels compared with the teachers and textbooks writers who corrupted the souls of children and thereby sentenced them to eternal death" (Numbers 2000: 315). This reaction by parents is not so outrageous as it may initially seem; they had good reason to think that the public schools would conform to their religious beliefs. Throughout the 19th and early 20th centuries, the public saw as a central mission of the public schools the socialization of America's children, including the reinforcement of religious (i.e., Protestant) norms. The "common school" movement of the mid-19th century, associated with Horace Mann, institutionalized a role for religion (i.e., Protestant values and morals) in the public schools, and Protestant bible passages were common in readers and primers of the time (Fraser 1999). This eventually stimulated Catholics and others to establish their own schools.

The public trauma of World War I also influenced the views of average American citizens regarding evolution, in that German militarism and its association with so-called Social Darwinism were seen as the direct offspring of evolutionary theory (Ruse 2000). Specifically, many Americans associated Darwinian natural selection with a survival-of-
the-fittest philosophy that justified laissez-faire capitalism, imperialism, militarism, and eugenics (Larson 1997). The horrors of the war caused many fundamentalists, in particular, to lose faith in progress and in science, and to blame the war on both the abandonment of traditional Christian morality and on the acceptance of Darwinism. Hence, anti-modernism and anti-evolution arose as central tenets of Fundamentalism (Marsden 1980).

The war and its aftermath (the rise of communism, worldwide labor unrest, and the apparent breakdown of traditional values) also stimulated a major change in the way conservative Christians lived their faith. The emphasis shifted from praying, evangelizing, and waiting for the end to a form of activism that necessitated going out and doing something to stop the social degeneration of the country (Larson 1997). The goal was to transform society with Christian values. This in turn led to the founding of the first explicitly fundamentalist organization, the World's Christian Fundamentals Association (WCFA), in 1919 (McIver 1989). The association worked vigorously, and successfully, for the ratification of the 18th Amendment to the Constitution, the prohibition against alcohol, part of the larger Progressive Era movement of the early 20th century that advocated campaign finance reform, anti-trust legislation, child labor laws and women's suffrage (Larson 1989).

**Fundamentalist Anti-evolution in the Schools**

Buoyed by the successful legal battle against godlessness in the form of alcohol, fundamentalists turned their attention to the outlawing of the teaching of evolution in public schools. The evangelical Christian religious movement of the 1920s came to be
dominated by fundamentalists "engaged in holy warfare to drive the scourge of modernism out of church and culture" (Marsden 1980: 141). Anti-evolution would be the rallying cry of this war.

This rallying cry was taken up by no less a personage than the enormously popular, thrice-defeated Democratic Presidential candidate and former Secretary of State (under Woodrow Wilson) William Jennings Bryan, and by 1930 over twenty state legislatures had debated outlawing the teaching of evolution, and five (Oklahoma, Florida, Tennessee, Mississippi, and Arkansas) had actually done so (Larson 1989). The controversy became so heated that at times it seemed as though "America might go mad" (Numbers 2000: 314).

Sudden creation was at the same time made more credible to many with the publication of self-trained geologist George McCready Price's *The New Geology* (Price 1923), in which he resurrects, with scientific-sounding language, Noachian flood geology as an explanation for earth's geophysical features, and with it Young Earth Creationism. Price testified at the notorious Scopes trial of 1925, where Bryan acted as special prosecutor for the state of Tennessee opposite Clarence Darrow and ACLU lawyers. At the heart of the trial was the issue of who was to determine the content of public school curricula. To the anti-evolutionists, the trial was about local, majoritarian control over the education and values of their children: "What right have the evolutionists—a relatively small percentage of the population—to teach at public expense a so-called scientific interpretation of the Bible, when orthodox Christians are not permitted to teach an orthodox interpretation of the Bible?" (W. J. Bryan, from Scopes trial excerpts in
The goal of the defense was to publicly debunk fundamentalist reliance on the Bible as a source of scientific information (Larson 1997). Scientists, like the anti-evolutionists, considered the central issue to be curriculum control, and viewed Scopes' defeat at the trial as indicating that "what is to be taught as science would be determined not by a consensus of the best scientific opinion, but by the votes of shopgirls and farmhands, ignorant alike of science and of the foundation principles of our civil society" (Holmes 1927: 554, cited in Nelkins 1982: 32).

Public opinion of the Scopes trial outcome, especially after the release of the Broadway play and subsequent film "Inherit the Wind," has been that religious fundamentalism was humiliated and discredited, and subsequently faded back into the shadows of the lunatic fringe. To the contrary, it can be shown that, in part because of the Scopes trial, fundamentalism continues to have an impact on the teaching of evolution in the 21st century.

While John Scopes was indeed found guilty of breaking state statutes against teaching evolution, the prosecution was unable to present a credible attack on evolution on either scientific or religious grounds, allowing both sides to claim victory, at least among their own supporters. The media circus around the trial drew a tremendous amount of attention to the issue, on the front pages of hundreds of newspapers worldwide for two weeks (Larson 1997). The death of Bryan less than a week after the end of the trial, rather than discouraging, galvanized his followers who rallied to carry on the fight. In the years immediately following the trial, four more states outlawed the teaching of
evolution; others directed textbook commissions to delete evolutionary theory from high school (Nelkins 1982).

However, this seems to have been a largely regional phenomenon. By 1930, those Southern and Western states or localities in which fundamentalists held political power had imposed anti-evolution restrictions, whether by legislation, administrative edict, or school board resolution. In the North, such efforts met with stiff resistance and were roundly defeated (Larson 1997). Rather than fading into the woodwork after Scopes, anti-evolutionism actually expanded to its maximum possible geographic extent, and once in place, no Southern anti-evolution restriction would be reversed for over forty years. In areas where fundamentalist anti-evolutionists held political sway, evolution was no longer being taught, so the legislative campaign was viewed as no longer necessary.

Following the trial, anti-evolutionists increasingly turned their efforts to “the emasculation of textbooks, the ‘purging’ of libraries, and above all the continued hounding of teachers” (Numbers 2000: 316). Their efforts were rewarded: research on biology textbooks between the late 1920s and 1960 shows that Darwinism virtually disappears from high school texts (Miller & Grabiner 1974; Skoog 1979). Two nationwide surveys of high school biology teachers in the early 1940s showed that fewer than 50% included any mention of evolution in their classes, and that teachers’ primary reason for avoiding evolution was fear of community pressure (Burnett 1941; Riddle 1942). The textbook situation would change dramatically, beginning in 1957, following the launch of the Russian Sputnik. Americans, shocked that their Cold War enemies had won the race for space, were able to see proof of their technological defeat on a nightly
basis from their own back yards as the satellite streaked through the night skies. This foreign achievement in space technology gave such a jolt to the American scientific and political communities that the National Aeronautic and Space Administration was immediately established and generously funded to accelerate American research on space travel (Dickson 2001). Additionally, the National Science Foundation (NSF) was directed to oversee a complete revision of American science curricula, and a new set of widely-used biology textbooks based on evolutionary theory was introduced by NSF’s Biological Sciences Curriculum Study (BSCS 1963; Nelkin 1982).

Following the ultimate failure of the anti-modernist crusades of the 1920s, fundamentalists were also regrouping in new ways. Coalitions of disparate fundamentalist groups that had united for the common goals of driving evolution from the schools and liberalism from the Protestant denominations had disintegrated. Once a respected evangelical movement within mainstream Protestantism, fundamentalism was no longer taken seriously in either ecclesiastical or secular discourse, and its followers were viewed as ideological outcasts (Carpenter 1997). Turning this outsider status to their advantage, however, fundamentalists were able to cast themselves (to themselves) as God’s chosen few, keepers of the faith, and duty-bound to lead America back to the path of righteousness. Rejection of the secular world was the common thread that now began to knit together diverse fundamentalist groups, and allowed them to maintain a solid base of popular support. Membership in fundamentalist churches actually grew in the middle decades of the 20th century, at a time when church attendance fell precipitously in the liberal Protestant denominations (Carpenter 1997).
Rather than fight existing religious and secular institutions with which they found themselves in philosophical conflict, fundamentalists essentially set about to establish their own subculture with independent religious, cultural, and social institutions. The 1930s saw the establishment of an institutional network of fundamentalist colleges and schools, foreign missions, publishing houses, journals, scientific societies, bible institutes, film production companies, and radio ministries (Marsden 1980; Carpenter 1997). After World War II, immensely influential national movements such as Youth for Christ and the Billy Graham urban revival meeting circuit, along with the establishment of the National Association of Evangelicals, pushed the sphere of fundamentalist revivalism ever wider. Keen instincts for popular appeal, mastery of the mass media of television and radio, and finely-honed marketing and communication skills explain the success of fundamentalists in leading a major upsurge of religiously-inspired conservative cultural politics beginning in the 1950s (Carpenter 1997). These institutions would flourish throughout the remainder of the 20th century, directed towards the time-honored goals of bringing a Christian revival to America and the gospel to the world.

A number of fundamentalist science organizations was also established post-Scopes, in the interest of generating creationist scientific theories: the Christian Research Society in 1923 (from which would arise the Institute for Creation Research, described below), the Religion Science Association in 1935, the Deluge Geology Society in 1936, and the American Scientific Affiliation (an organization of evangelical science educators) in 1941 (Larson 1997).
Modern Fundamentalist Creationism: “Creation Science.” Henry Morris and the Institute for Creation Research

As described above, statutes outlawing the teaching of evolution in the public schools had reached their geographic and political limits in the 1930s, and, their mission seemingly accomplished, fundamentalist creationists continued to work and flourish, but without much public attention. They would surface again as a fighting force in the 1960s, in response to mounting legal challenges to standing anti-evolution legislation. The success of this response, in the form of efforts to mandate equal time for “creation science,” is credited in large part to the efforts of Henry Morris.

The re-emergence on the public stage of vocal fundamentalist anti-evolution, and the birth of the modern creation-science movement is marked by the publication in 1961 of The Genesis Flood: The Biblical Record and Its Scientific Implications by John Whitcomb and Henry Morris, the latter a professor of civil engineering and the widely acknowledged founding father of modern creation science. In it, the authors present an updated version of George McCready Price’s (1923) Flood Geology, and yet another resurrection of a young-earth, six-literal-days form of creationism. Morris’ position as a scientist and university professor gave creationist views an appearance of legitimacy they had not previously enjoyed. The Creation Research Society (CRS) was formed the same year, admitting only accredited scientists to its ranks, dedicated to strict creationism, and publishing its own quarterly journal with the goal of developing scientific explanations that would support a literal interpretation of Genesis (Marsden 1980)—another example of the fundamentalist strategy of rejecting participation in the mainstream and creating its own institutions. In 1970, the Creation-Science Research Center (CSRC) spun off from
CRS in order to produce a series of creationist biology textbooks in response to the BSCS books (McIver 1989). These were authored by Morris with contributions from a chemistry professor from the University of Iowa and an entomologist from Oregon State (Boardman et al. 1971). The books were adopted as “supplemental educational materials” in 28 states during 1973-74 (McIver 1989).

The best-known creation-science organization, the Institute for Creation Research (ICR), split off from the CSRC in 1972, and has been headed by Henry Morris and Duane Gish from its inception. According to John Morris, son of Henry and current director of the institute, ICR’s mission is

...to discover and transmit the truth about the universe by scientific research and study, and to correlate and apply such scientific data within the supplemental integrating framework of Biblical creationism. We believe God has raised up ICR to spearhead Biblical Christianity’s defense against the godless dogma of evolutionary humanism. Only by showing the scientific bankruptcy of evolution, while exalting Christ and the Bible, will Christians be successful in "the pulling down of strongholds; casting down imaginations, and every high thing that exalteth itself against the knowledge of God, and bringing into captivity every thought to the obedience of Christ" (II Corinthians 10:4,5). (J. Morris 2001)

ICR offers non-accredited graduate degrees in astro/geophysics, biology, geology, and science education, and maintains a museum of creation and earth history. The Institute also produces hundreds of books, videos, audiocassettes, and home-schooling materials, which are for sale on its on-line store, and it maintains its own radio ministry broadcast in 45 states by hundreds of stations (ICR 2001). Although scientific research produced at the center has not yet passed muster at any mainstream peer-reviewed scientific journal, results of such endeavors are published in ICR’s monthly journal, *Acts & Facts*. 
Creation Science: The New Legal Battles

What has been the impact of these fundamentalist Christian individuals and organizations, from the fringes of both modern science and modern theology, on the teaching of evolution in America's public schools in the late 20th century? Attempts to outlaw the teaching of evolution ultimately failed, as all of the anti-evolution laws from the 1920s were eventually overthrown. The U.S. Supreme Court declared Arkansas' law forbidding the teaching of evolution (Arkansas 1928) unconstitutional in 1968 (Epperson v. Arkansas; see Moore 1998c) on the grounds that it violated the First Amendment guarantees of free speech. Mississippi's law forbidding the teaching of evolution and mandating the firing of any teacher who taught evolution (Mississippi 1926) was overthrown by the state's Supreme Court in 1970 on similar grounds (Smith v Mississippi).

Once it became apparent that efforts to outlaw the teaching of evolution were futile, creationists needed a new strategy; this new tactic was to insure coverage of creationism in science classrooms whenever evolution was taught, ostensibly in the interests of fair play. Based on a model provided by the ICR (Morris n.d.), bills advocating that equal time be given to 'evolution science' and 'creation science' were introduced in 26 state legislatures, in some cases multiple times, during the 1970s and 1980s (Scott 1997). These bills proposed that, whenever the theory of organic evolution was introduced in class, an equal amount of time be devoted to the 'creation science' theory of sudden, recent creation, and Noachian Flood geology.
Two states, Arkansas and Louisiana, adopted the bills and soon had to defend their decisions in court. In 1982, Arkansas's equal-time bill was declared unconstitutional in U.S. District Court (McClean v. Arkansas) and 'creation science' ruled to be religion, not science. Interestingly, the plaintiffs (i.e., those opposing the equal time bill) consisted of a Methodist minister, and several Roman Catholic and Episcopalian bishops, along with leaders of other Protestant and Jewish ministries. In 1987, the U.S. Supreme Court likewise rejected Louisiana's equal-time law (Edwards et al v. Aguillard), this time on the grounds that it violated the establishment clause of the First Amendment of the Constitution by promoting inherently religious ideas (Larson 1989; Moore 1999b). This was the last courtroom challenge to evolution, and seems to have effectively killed efforts by creationist groups to legislate "equal time."

Neocreationism and "Intelligent Design Theory"

After these important legislative defeats, another strategy change was required by anti-evolutionists—what has been referred to as Neocreationism (Scott 1997). This entailed a revision of creationist language to avoid any overtly religious terms, preferring instead "alternatives to evolution," "evidence against evolution," and "intelligent design theory," and eschewing any explicit reference to a "creator" (Scott 1997; Moore 1999b). In most cases, it is not the creationist message that has changed, merely the terminology. However, this new approach has also attracted new supporters, some with impressive academic credentials that add a new legitimacy to the creationist movement, and make it more broadly attractive, for example to those unwilling to reject all scientific findings regarding the age of the earth, uniformitarian geological processes, etc. This new form of
anti-evolutionism has been referred to as "the cryptoscientific arm of a sociopolitical movement of Conservative Christians...upset about the displacement of their concept of God from institutional life in the United States and ... determined to do something about it" (Padian 2002: 2373).

The best known supporters of this form of "intelligent design theory" are Phillip Johnson, retired professor of criminal law from the Boalt School of Law at UC Berkeley, and Michael Behe, professor of biochemistry at Lehigh University—both well-respected secular institutions of higher learning. Each man is a highly regarded academician, articulate and persuasive, and each has written popular but highly criticized books that insist on a role for God, and a divinely directed purpose for life, but that reject the six-literal-day, Noachian Flood Geology form of creationism (Johnson 1993; Behe 1996). Both also see evolutionary theory as the dangerous manifestation of a materialist and naturalist worldview, that is itself at the root of the degeneration of human society, and that must be replaced with a God-guided worldview.

The ID movement is well-organized and well-funded, with a clearly articulated manifesto. Based in the conservative think-tank, the Discovery Institute’s Center for the Renewal of Science and Culture (CRSC), it has an annual budget in the multiple seven-figures, due in large part to generous contributions from extreme right-wing fundamentalist Christian organizations and individuals (Forrest 2001).

The so-called Wedge Strategy of the ID movement is to drive a wedge between science/scientists/the public and materialism as a methodology, and to replace “evolutionary naturalism” with “theistic realism” as a way for doing science. It must be
noted that proponents of ID regularly conflate methodological and philosophical materialism—i.e., the *practice* of relying only on natural explanation to explain natural phenomena (and thus eschewing supernatural explanations), as opposed to the *philosophy* that nothing exists beyond the natural. Methodological materialism is a necessary foundational underpinning of the practice of science; philosophical materialism, on the other hand, is seen as denying the existence of a God.

The Wedge strategy has three stated phases of projects/goals: Phase I is scientific research, writing, and publication; Phase II consists of efforts to influence public opinion through book publicity, opinion-maker conferences, apologetics seminars, *teacher training programs* [emphasis added], PBS or other TV co-production, etc.; and Phase III directs its efforts towards “culture confrontation and renewal”, including academic and scientific challenge conferences, potential legal action for teacher training, and a shift to social sciences and humanities research fellowship support (CRSC 2000).

Thus far, nothing has come of Phase I efforts at producing scientific research from an ID perspective, if such efforts have been undertaken; no paper with an ID theoretical basis has yet been published in a refereed scientific journal (Forrest 2001). The other phases, however, are in full swing. Johnson’s and Behe’s books (*Darwin on Trial, Reason in the Balance, Darwin’s Black Box*) alone have sold hundreds of thousands of copies through mainstream retailers such as Barnes and Noble and Amazon.com, as well as through the Discovery Institute’s website (CRSC 2000). This website is also the primary conduit for “science education resources” that purport to provide teachers with current, scientific evidence in support for ID, and advice on curriculum development to
include ID. The website also indicates plans to present these curricula to NABT, NSTA, and other science education professional organizations (CRSC 2001).

With regards to influencing public opinion, Johnson, Behe and other prominent ID proponents have published op-ed pieces in *The Wall Street Journal, The Chronicle of Higher Education, The New York Times, The Washington Times, and The Washington Post*, as well as in mainstream religious publications such as *World Magazine* and *Christianity Today* (see Forrest 2001: 27 for complete citations). Behe and Johnson have also been invited to participate in PBS's *Technopolitics* series, *NOVA Online, Freedom Speaks*, and *Firing Line*, as well as programs on the History Channel, dramatically increasing their public exposure (Forrest 2001). As of 2001, CRSC fellows have also organized and participated in major conferences at Southern Methodist University, Biola University, Baylor University, University of Texas-Austin, Concordia University, and Yale.

It is important to note, despite all protestations to the contrary, that the Wedge strategy, and the ID movement as a whole, is not really about science:

Paradoxically, they are pursuing their remedy for "scientific naturalism" from *outside science*. They are not attempting to change the way science is currently done by introducing *better* methodology or more viable hypotheses... Rather, they are trying to change the way the public and influential policy-makers *perceive* science through their aggressive program of public relations activities. This is crucial to their strategy. (Forrest 2001: 32; emphases in the original)

The seeming legitimacy of this university-based brand of anti-evolution gives creationist groups new and powerful ammunition when they go before school boards to make the case that evolution is rejected by prominent scientists at secular institutions, that
it is therefore a “theory in crisis,” and should be presented in conjunction with other
theories of the origin and diversity of life. And make use of it they do: the National
Center for Science Education, a major supporter of evolution education, reports requests
for assistance throughout the 1990s from schools and districts from dozens of states
nationwide wrestling with equal-time provisions (Scott 1997; NCSE 1999).

This strategy of targeting school boards and curriculum committees rather than
legislatures has born fruit. The states of Arizona and New Mexico revised state science
curriculum guidelines in 1997, removing any reference to evolution, although the new
guidelines were ultimately not adopted (Rissing 1998). However, in 1999, Kansas and
Kentucky successfully removed reference to evolution and the ‘Big Bang’ theory of
cosmology from state ‘standards’—guidelines for what students must know for
graduation (Holden 1999; Moore 2000a). This move in Kansas was also ultimately
undone, as the school board responsible was ousted at the next election, and evolution
was reinstated. We might well wonder what impact all of the public furor over the
teaching of evolution has had on teacher practice at the turn of the millennium.

The following chapter examines one possible measure of the impacts that all of
these activities by creationist groups, state legislatures, school boards, curriculum
advisory committee have had from the 1940s through the present day on actual classroom
content—i.e., the teaching of evolution and creation by public school biology teachers.
CHAPTER FOUR

Status of Anti-evolution in the Classroom: Surveys of Teachers

Polling teacher behavior and attitudes regarding the teaching of evolution in the United States began at least by the early 1940's. Tracking trends and patterns in these data is somewhat problematic because the available published surveys vary widely in methods and topics, and early publications are very sparse in specifics, particularly quantitative data. The questions posed to the subjects differ, and the types of information provided in the publications vary considerably. Some studies do not provide return rates or sample sizes. Many used non-random samples, for example relying on membership rolls of professional societies. This is problematic because recent studies have shown that professional association members were much more likely to view evolutionary theory as central to biology than were teachers without such memberships; conversely, those teachers with no professional association memberships were much more likely to emphasize creation in the classroom, and more likely to agree that there is much scientific evidence for creationism (Aguillard 1998; Buckner 1983; Weld & McNew 1999). Thus, studies that relied on professional membership roles for their samples may overestimate emphasis on evolution, and underestimate support for creationism among the nation's high school biology teachers.

Appendix A provides information on the sampling techniques, return rates, sample sizes, and limitations of all of the available studies of this type: 30 surveys spanning the years 1941-2000. Twenty-three of these studies involved high school
biology teachers; the remaining seven involved college students, in two cases senior biology education majors. These latter studies were included in order to characterize attitudes of educated Americans in general, and future teachers in particular.

**Early Surveys: 1940s-1970s**

The earliest studies (Burnett 1941; Riddle 1942) both involve very large, national samples drawn from professional membership lists, which, as mentioned above, probably overestimates emphasis on evolution. Nonetheless, both researchers found that the majority of American biology teachers were avoiding the topic of evolution, most due to fear of community disapproval. Two very different studies in the 1950s appear to give conflicting results: Laba and Gross (1950) found that 72% of very small sample of New Jersey teachers covered evolution (although a third of them believed that evolution was due to supernatural causes), while a larger national sample of high schools showed that fewer than 9% of American biology classes included evolution as a topic (Martin 1951). Taking into account the poor sampling techniques in the 1940s’ studies, and the non-representative nature of the New Jersey survey (it is unlikely that the responses of 29 teachers in one Northeastern county represent the attitudes and behaviors of teachers in the deep South, for example), it seems reasonable to conclude that anti-evolution legislation, and the absence of evolution in textbooks in the years following the Scopes trial, had effectively removed the topic from all but a very few American classrooms in those decades.

The only study contemporaneous with the release of the new evolution-based BSCS textbooks of the early 1960s showed that 75% of Indiana teachers were including
evolution, although only 12% believed it was a unifying principle in biology, and 50% favored "equal time" for alternative theories (Troost 1966). This study, too, may be overestimating emphasis on evolution due to its biased use of professional association membership rolls.

Little seems to have been published on this topic again until the 1980's. Some interesting studies of college students on the topic of evolution during this hiatus, however, point not only to the attitudes of educated Americans, but represent to a limited extent the population from which new high school teachers were drawn. A study that measured student attitudes over quite a long period, from 1935-1973, found that the percentage of undergraduates at Brigham Young University embracing the idea that the origin of man did not include evolution increased from 36% to 81% over that time period (Christenson & Cannon 1978). In another example, nearly all (94%) of student science teachers in their final year at Bowling Green State University in Ohio favored the inclusion of creationism in the science curriculum (Bergman 1979). Additionally, less than half of more than 2000 Ohio State University undergraduate science students accepted evolutionary theory as scientifically valid, and 22% expressed the belief that the teaching of evolution could lead to moral decay in American society (Fuerst 1984).

**Surveys in the 1980s**

Polling of teacher attitudes and behaviors with regards to evolution reemerged in the early 1980s with a flurry of studies, probably in response to 1) the increase in legislative action related to the teaching of evolution, 2) research showing the poor state
of science education, and 3) research showing another reduction in coverage of evolution in textbooks in the 1970s.

During the late 1960s and 1970s, as described above, teachers began rebelling against state laws still on the books from the 1920s, barring the teaching of evolution or attempting to mandate "equal time" for creation science whenever evolution was taught. In fairly short order (fewer than 15 years), it was ruled to be unconstitutional both to forbid the teaching of evolution, and to require the teaching of creationism as science in public school classrooms.

At about the same time, a serious crisis in science education was recognized in the publication of *A Nation at Risk* (National Commission on Excellence in Education 1983). A two-year assessment of the state of American education painted a fairly bleak picture of the quality of that education, both in comparison to other industrialized nations (in which the U.S. often ranked last), and in time-series, where the study found steady declines in SAT scores, college board exams, and science and math achievement scores from the 1960s onward. The report also found teacher preparation curricula to be too heavily weighted with "educational methods" at the expense of subject matter training, and found a severe shortage of qualified math and science teachers. These results were reported widely, and garnered a great deal of public attention.

It had also become clear that, despite BSCS efforts, groups lobbying textbook publishers to sharply reduce coverage of evolution, particularly in the huge client states of California and Texas, had had some success (Skoog 1984a, 1984b; Nelkin 1982;
Moore 1998b). There was concern that this was contributing to poor-quality education in biology, and was a hindrance to teachers who relied heavily on textbook content.

The confluence of all of these factors—increased legislative activity, concern for the scientific literacy of American students, and concern about the reduction in coverage of evolution in the nation's biology texts—seems to have stimulated a resurgence in interest in the polling of American teachers regarding the teaching of evolution by the 1980s, when nearly half of all published studies were conducted. In addition, for the first time, researchers began asking questions not just about the teaching of evolution, but about the teaching of creationism as well.

**Emphasis on Evolution**

Studies throughout the 1980s show that, while in most cases the majority of teachers was including some discussion of evolutionary theory in their classrooms, a significant minority spent little or no time on the topic. A significant minority also taught creationism, believed that creation science is scientifically valid, doubted the centrality of evolutionary theory to the study of biology, or rejected the scientific validity of evolution.

There are no regional differences apparent among the three surveys of Southern teachers or those conducted in Mid-western states in the 1980s (see Appendix A for sampling methods and other details). In all cases, a majority of teachers spent some time on evolutionary theory, but many were seen to be de-emphasizing the topic: one-third of Kentucky teachers, one-quarter of Tennessee teachers (Ellis 1983), and 45% of Ohio teachers (Zimmerman 1987) spent little or no time on it. A large national sample of biology teachers also showed that 36% failed to emphasize evolutionary theory by
devoting fewer than 2 class periods to it (Shankar 1989). This finding is especially striking in that it drew its sample from professional association membership lists, which, as discussed above, almost undoubtedly overestimates the support for evolution; we may conclude, that in actuality, a large number of the nation's biology teachers spent very little time discussing evolution.

A significant minority of teachers also expressed doubts about the scientific validity of evolutionary theory or its centrality to the study of biology—doubts not shared by the scientific community, and thus an indication that the nation's educators were out of step with the scientific consensus of their discipline. Nearly half of a sample of Atlanta-area biology teachers (Buckner 1983), and a quarter of teachers surveyed from Ohio (Zimmerman 1987) and South Dakota (Tatina 1989) rejected the scientific validity of evolutionary theory. An equal proportion (one-quarter) of Arkansas and Missouri biology teachers did not think that evolutionary theory was central to an understanding of biology (Roelfs 1987). This was also the case for 20% of a national sample of teachers (Affannato 1986)—this latter sample also drawn from professional membership roles and perhaps overestimating support for evolutionary theory. A significant minority of biology teachers across the country doubted the scientific validity of the central organizing principle of their discipline, and demonstrated a surprising lack of familiarity with the abundant molecular, paleontological, anatomical, and embryological support for evolutionary theory.
Support for Creationism

There is also evidence of well-established creationist beliefs within the biology teacher population in the 1980s. Nearly one-third of a sample of Georgia teachers (Eglin 1983) reported teaching creation as part of their biology classes while about a fifth of Ohio (Zimmerman 1987) and South Dakota (Tatina 1989) teachers also reported doing so. The three national samples from this time period provide some interesting data on this topic, reporting that 47% (Nelkin 1982), 43% (Affannato 1986), or 28% (Shankar 1989) of teachers taught creation as part of their biology classes. This result is especially intriguing since all three samples were drawn from membership lists of the same professional association (National Science Teachers Association), and seem to document a steady decline in teaching creation throughout the 1980s. Unfortunately, these studies did not discriminate amongst teachers who just mentioned creation, those who discussed the potential conflict between evolution, and those who taught creation as an alternative scientific theory and gave it "equal time."

In all of the above-mentioned studies, a higher percentage of teachers than actually taught creation thought that creation should be taught in the public schools—anywhere from 2 (Eglin 1983) to 20 percentage points more (Zimmerman 1987). Presumably, there are teachers who either feel restrained from teaching creation, or who think someone other than themselves should do the teaching. Thirty percent of a random national sample of teachers professed to prefer to teach creation only (Fisher 1989). In all the studies that addressed this question, it appears that more teachers believed it appropriate to include creation than were actually doing so, although none of the authors
offers an explanation. Favor for "equal time" for evolution and creation seems to have been quite high in the 1980s: Van Koevering and Stiehl (1989) found that 87% of their random sample of Wisconsin biology teachers favored "equal time," as did a third of Illinois teachers (Nickels & Drummond 1985). An average of nearly 40% of teachers from three surveys conducted in the Mid-west, South, and Northeast supported the notion that creationism should be taught in the public schools (Eglin 1983; Zimmerman 1987; Tatina 1989).

Perhaps even more revealing are those studies that document specific creationist beliefs amongst biology teachers in the 1980s. At a science teacher's conference in Illinois, researchers found that about one-third believed that a recent, worldwide flood adequately explained the fossil-bearing strata on earth (a prominent feature of Young Earth Creationist flood geology), and 20% accepted the Bible as a reliable source of scientific information on the age of the earth and the origins of life (Nickels & Drummond 1985). As with the criticism leveled at survey samples drawn from professional association membership lists, a case can be made that teachers motivated to attend a non-mandatory conference may be more scientifically literate than non-attendees, and that favor towards creationist beliefs may actually be underrepresented in this study.

Significant minorities of teachers throughout the 1980s also expressed the belief that creationism is a scientifically valid theory: three national surveys, all with samples drawn from the NSTA, showed that 39% (Nelkin 1982), 15% (Affannato 1986), and 27% (Shankar 1989) of high school biology teachers believed that there was much
scientific evidence in support of creation. Thirty-four percent of South Dakota teachers agreed (Tatina 1989), as did 17% of Ohio teachers (Zimmerman 1987). As there is no scientifically accepted evidence for the sudden appearance of all life forms or a young earth, these findings seem to illuminate a fundamental misunderstanding of the criteria for scientific evidentiary claims amongst a significant proportion of American biology teachers.

**Surveys from 1990-2000**

Efforts to influence the content of public school biology curricula by anti-evolutionist groups continued unabated in the 1990s; not surprisingly, an additional six surveys of teachers regarding this issue were conducted in the decade ending in 2000, including two conducted in Southern states, one Northeastern state, two Midwestern states, and one nationwide (see details in Appendix A).

The pattern that emerges does not differ significantly from that discerned for the 1980s. While a strong majority of teachers in all the studies reported that they spent some time on the topic of evolution, a significant minority (39% in a national sample, 16% in Louisiana, and 25% in Indiana) rejected the scientific validity of evolutionary theory (Eve & Dunn 1990; Aguillard 1998; Rutledge & Ward 2000). At least one-third of teachers in three separate studies, encompassing the South, the Northeast and the Midwest, did not believe that evolution is central, or even important, to the study of biology (Miller 1990; Osif 1997; Weld & McNew 1999).

Between one-quarter and one-half of all teachers in these surveys also believed that there is a great deal of scientific evidence in support of sudden creation, or believed
that the Bible is a reliable source of scientific information on the age of the earth and the
origin of life (Eve & Dunn 1990; Aguillard 1998; Weld & McNew 1999; Rutledge &
Ward 2000). Somewhere between one-quarter and one-third of teachers in national,
Southern and Midwestern surveys reported that they taught creation, although it is not
clear in what context, as discussed above (Miller 1990; Aguillard 1998; Weld & McNew
1999. Thus the steady decline in teaching creation reported throughout the 1980s seems
to have leveled off in the following decade. A slightly higher proportion of biology
teachers (around 40%), as in the 1980s studies, thought that creationism should be taught
in the public schools (Eve & Dunn 1990; Osif 1997), again implying that teachers either
felt constrained from teaching a topic they favor, or felt it should be taught by someone
else.

Most interesting of all was the finding in 1997 that in a random sample of
Pennsylvania biology and English teachers, training in the biological sciences did not
make any difference in the acceptance of the importance of evolutionary theory; equal
proportions (33%) of both types of teachers felt it was unnecessary to an understanding of
biology (Osif 1997). Additionally, a greater percentage of biology teachers (43% vs.
38% of English teachers) favored the teaching of creation.

As in the 1980s, a significant proportion of high school biology teachers in the
last decade of the 20th century seemed unfamiliar with the scientific evidence in support
of evolutionary theory, and was unconvinced of its centrality to the study of biology.
Only around 10% correctly identified the description of evolution from multiple-choice
lists (Zimmerman 1987; Tatina 1989), and most fared poorly on questions about the
nature of science, as well (Rutledge & Warden 2000).

These findings raise a number of questions. Is the lack of teacher support for the
teaching of evolution due to shortcomings in their own educations, or, as Osif found,
does training in biology make no difference? What accounts for the relatively high
proportion of teachers who favor the teaching of a non-scientific theory (creationism) that
has been declared so by the Supreme Court of the United States—is it pressure from
others, or personal religious conviction?

The following chapters describe a study begun in February 2000, designed to
answer these questions. A census was conducted of the public high school biology
teachers in the state of Arizona, seeking to identify variables or suites of variables that
contribute to teacher attitude and behavior with regard to the teaching of evolution and
creation. No studies of a Western state have been published on this topic to date.
Additionally, the survey came directly on the heels of a nearly successful effort to
remove the topic of evolution from the Arizona State Curriculum Standards (or
guidelines). It seemed a particularly favorable time to ascertain what teachers did with
regard to teaching evolution and creation, what they believed about those topics’
relevance to biology, and how they responded to the political and social issues
surrounding these topics. The results of the survey characterize the amount of emphasis
teachers give in the classroom to evolution and creation. Additionally they offer insights
into aspects of teacher educational backgrounds, religious beliefs, and attitudes towards
evolution and creation, as well as aspects of the school communities in which teachers
work, that drive teacher behavior in the classroom. This in turn can be used to make a positive contribution to the modification of teacher training curricula to better prepare the future biology teachers of America to confidently communicate the central tenets of their chosen discipline to their students.
CHAPTER FIVE
RESEARCH DESIGN AND METHODS

This chapter describes the objectives of the survey research, the specific hypotheses that were tested, and details of the research design, including the study population, the questionnaire and survey methods, and tests of non-response bias. The particular statistical methods utilized are also specified.

Objectives

Descriptive Objectives

As stated in the previous chapter, the objectives of the study were to determine the status of evolutionary theory and creationism in Arizona public high schools by ascertaining and describing

1) the self-reported amount of emphasis given each topic by biology teachers,
2) the level of understanding of evolutionary theory on the part of biology teachers,
3) the attitudes of teachers towards evolution and creation,
4) whether teachers feel pressured regarding the teaching of evolution or creation, and by whom,
5) whether teachers feel adequately prepared to teach evolutionary theory, and
6) what teachers are willing to do to improve their understanding of evolutionary theory.

Hypothesis Tests

An additional set of goals was to test hypotheses regarding relationships between
the primary dependent variables and various independent variables, including
demographic features of teachers and the school communities in which they work. The
purpose was to identify which independent variables (i.e., demographic feature or suite of
features) may lead teachers to emphasize evolution or creation. The hypotheses are
displayed in Table 5.1, below.

Table 5.1: Hypotheses Tested Regarding Teacher Emphasis
on Evolution and Creation

<table>
<thead>
<tr>
<th>Emphasis on evolution is related to:</th>
<th>Emphasis on creation is related to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1: teacher educational background</td>
<td>2.1: teacher educational background</td>
</tr>
<tr>
<td>1.1A: highest degree achieved</td>
<td>2.1A: highest degree achieved</td>
</tr>
<tr>
<td>1.1B: degree in biological sciences</td>
<td>2.1B: degree in biological sciences</td>
</tr>
<tr>
<td>1.1C: coursework in evolutionary biology</td>
<td>2.1C: coursework in evolutionary biology</td>
</tr>
<tr>
<td>1.2 teaching experience</td>
<td>2.2 teaching experience</td>
</tr>
<tr>
<td>1.3 in-service training in teaching evolutionary theory</td>
<td>2.3 in-service training in teaching evolutionary theory</td>
</tr>
<tr>
<td>1.4 religious denomination</td>
<td>2.4 religious denomination</td>
</tr>
<tr>
<td>1.5 religious fervor</td>
<td>2.5 religious fervor</td>
</tr>
<tr>
<td>1.6 attitudes toward evolution</td>
<td>2.6 attitudes toward evolution</td>
</tr>
<tr>
<td>1.7 attitudes toward creation</td>
<td>2.7 attitudes toward creation</td>
</tr>
<tr>
<td>1.8 gender</td>
<td>2.8 gender</td>
</tr>
<tr>
<td>1.9 age</td>
<td>2.8 age</td>
</tr>
<tr>
<td>1.10 features of school communities</td>
<td>2.10 features of school communities</td>
</tr>
<tr>
<td>1.10A: school size</td>
<td>2.10A: school size</td>
</tr>
<tr>
<td>1.10B: student ethnicity</td>
<td>2.10B: student ethnicity</td>
</tr>
<tr>
<td>1.10C: student socio-economic status</td>
<td>2.10C: student socio-economic status</td>
</tr>
<tr>
<td>1.10D: dominant religious denomination of community</td>
<td>2.10D: dominant religious denomination of community</td>
</tr>
</tbody>
</table>
Participants

The participants in this research project were biology teachers in Arizona public high schools, including charter schools. Arizona was selected for reasons of accessibility to the researcher, as well as for the freshness of the subject to this population. The Arizona Board of Education had revised the science curriculum guidelines for the state schools in early 1999, omitting any reference to evolution; subsequent vigorous, and very public, debate caused the State standards to be revised with evolutionary theory reinstated. Public school teachers were no doubt highly aware of the public debate, and many participated in letter-writing campaigns and testimony before the Board of Education.

The Arizona Department of Education supplied a list of all public (including charter) high school in September of 1999. Data provided included names, addresses and phone numbers for each public high school, along with size and ethnic composition of the student bodies, for the academic year 1998-1999, the most current data available. All of the private schools in the Tucson area (as of February, 2000) were also included for comparative purposes; since there is no central listing agency for private schools, a more comprehensive statewide sample was deemed unfeasible.

Once the population of schools was established, it was necessary to contact each school directly to ascertain the names of the biology teachers. Of the total of 230 schools, ten were eventually dropped because phones had been disconnected (several charter schools had apparently closed), or repeated phone messages over several months were not returned. The final population included 733 teachers at 220 schools. It was determined
that a census was feasible (both logistically and financially), and desirable, since there
would thus be no question of the representativeness of a sample, beyond possible non-
response bias. The current study also improves on many of the studies discussed in the
previous chapter that relied on membership rolls from professional organization; all
Arizona biology teachers were included, not just those motivated to join professional
societies.

Research Design

Mail-in Questionnaire

A self-administered, mail-in questionnaire was chosen as the most effective
method of achieving the objectives described above—i.e., gathering data on teacher
attitudes and practices regarding the teaching of evolution, and assessing potential
causative variables. Mail surveys are most appropriate when large sample sizes are
needed, and when subject matter is sensitive (deVaus 1996). Teachers in the study were
being asked to express their views and practices on a controversial topic (and in essence,
to reveal whether or not they were doing their jobs), and were being asked to reveal
sources of pressure from others within their schools and communities. Only with mail
surveys can subjects be assured of anonymity and confidentiality, and therefore
encouraged to give completely honest responses. The economy of this mode of research,
in both time and money, especially in comparison to personal interview, was also a
consideration.

The interpretation of this type of survey data depends, ultimately, on the
demonstrated representativeness of the returned questionnaires, or, more precisely, the
representativeness of the respondents. The question is, do the respondents to the
questionnaire differ in any significant way from the non-respondents? If so, the survey
results will be biased and will not truly represent teacher practice or attitude. While low
return rate can lead to results of doubtful representativeness, non-response bias (possible
systematic bias in non-respondents—i.e., individuals with shared characteristics or
attitudes self-selecting themselves out of the sample by failing to respond) is the primary
concern. Although low response rate, in and of itself is not biasing, as long as there is no
non-response bias, every attempt was made to maximize the return rate. The potential
problem of non-response bias is addressed below.

**Response Rate**

Since not all subjects of a mail-in questionnaire-based study return their
completed questionnaires, there is a possibility that all viewpoints will not be represented.
In particular, there is a concern that rare viewpoints will be missed. One way to lessen
this type of bias is to achieve the highest response rate possible, under the circumstances.
With a mail-in questionnaire, a response rate of 50% is considered adequate, 60% is
considered good, and 70% or more is considered very good (Babbie 1990: 182). The
potential problem of low-return rate was addressed in the present study by
implementation of the Total Design Method (Dillman 1978; Salant & Dillman 1994),
which specifies a closely grouped sequence of mailings and follow-ups. Thus, the first
mailing, consisting of a cover letter explaining the project, the questionnaire (Appendix
B), and a self-addressed, stamped envelope, was mailed out to all subjects in care of their
schools, in mid-February 2000 (it was deemed prudent to avoid both the hectic beginning
and end of the semester); a reminder card was sent out two weeks later, in early March, to all subjects, thanking those who had returned the questionnaire, and urging those who had not returned it to do so. Each questionnaire had been numerically coded to a particular teacher so that responses could be tracked; in mid-March, a second copy of the questionnaire, along with a second, more imploring letter, was sent to all teachers who had not yet responded. The letter also asked that those who did not wish to participate return the questionnaire with some indication of why they did not wish to participate (e.g., "too busy," "don't teach biology," etc.).

After questionnaire returns dwindled off, the school of each non-respondent was contacted by telephone, to ascertain whether or not the individual still taught there, and whether or not they taught biology classes. This resulted in the original population size being trimmed from 733 to 646, of which 420 responded. This 65% return rate falls into the good to very-good category (Babbie 1990), and was considered to have minimized return rate bias.

**Analysis of Non-response Bias**

The most important source of bias in questionnaire research is the possibility that there will be systematic bias in the people who chose not to participate—i.e., a particular segment of the study population, with shared characteristics, is not represented. The standard method of testing for non-response bias is to compare respondents to non-respondents on some key variables—the challenge being that, since the non-respondents did not respond, little is known about them. There are two main approaches to solving this problem: 1) contacting a sample of the non-respondents and inducing them to
respond to a shorter set of questions (essentially, turning them into respondents), or 2) comparing the two groups on factors already known about them (de Vaus 1996). The latter approach was chosen for the present study for several reasons. No means of contacting teachers other than through the schools was available, and each non-respondent had already failed to respond to three separate mailings and multiple phone calls. The literature on tests of non-response bias in social science research also reinforced the notion that contacting the non-respondents was probably not necessary. Dillman (1978) and Bailey (1987) both assert that the decision to respond or not to a questionnaire is based on the recipient's perceptions of costs (of participating; usually time), rewards (of filling out the questionnaire, which can be quite ephemeral), and trust (of the researcher, e.g., to maintain confidentiality), rather than real attitudinal differences. Bailey (1987: 159) does maintain, however, that there is a consensus, based on a heterogeneous sample of studies, that the least interested are the least likely to respond, making the distribution of respondents somewhat bimodal: those feeling strongly for or against the issue responding, and those indifferent to it refraining. It is possible, then, that the indifferent middle is underrepresented.

Nonetheless, many of well-known criticisms of non-response bias in questionnaires mailed to the general public do not apply to this specialist population of high school biology teachers, who are relatively homogeneous with regards to education levels, incomes, access to mail service, and familiarity with the topic (Bailey 1987: 149-172). In addition, prior studies, based on very similar questionnaires to very similar populations on the same topic (teaching of evolution/creation), have shown that the non-
respondents do not differ significantly in either practice or attitude from respondents (Affanato 1986; Aguillard 1998). The main reason given for failure to return the original questionnaire was lack of time or a dislike of questionnaires in general.

In order to assess the possibility of non-response bias in the present study, a number of variables was assembled for the non-respondent teachers. The following was known about each teacher in the sample: 1) whether or not they responded to the questionnaire; 2) their gender (in most cases); 3) the type of school in which they taught (public, charter, private); 4) the size of the student body 5) the ethnic make-up of the student body; 6) the socio-economic status of the student body (as represented by the percentage of the student body receiving state-subsidized school lunches); 7) the school setting (urban/suburban, small-medium town, rural); 8) the county in which the teacher worked (addressing potential regional differences in willingness to participate, since Arizona is a highly heterogeneous state in population distribution); and 9) the dominant religious denomination in the county (being either >50% Mormon, >50% Catholic, or from 25-50% Catholic; derived from census data). The latter criterion was of interest because of the religious and political conservatism associated with Mormonism.

The questions that can be answered using these data are whether gender, type of school, size of student body, student ethnicity, socio-economic status of student body, school location in a particularly sized community, a particular county, or in a particular religiously-dominated setting influenced whether a teacher was more or less likely to respond to the survey.

The method of analysis for most of the variables was cross-tabulation using
Pearson's chi-square ($\chi^2$) to compare the distributions of the categorical dependent variable of group membership (respondent/non-respondent) within the categorical, independent variables of gender, school type, dominant school ethnicity, school setting, county in which school resides, and dominant religious denomination of county. There were also two continuous variables: size and socio-economic status of school body. The former, which was not normally-distributed, was converted to a categorical variable, using quartiles, and evaluated using Pearson's chi-square; the latter, socio-economic status, was normally-distributed, and could be evaluated using an independent sample t-test of equality of means. All tests were performed using SPSS version 10.0.

At the 0.05 significance level ($p$), null hypotheses ($H_0$) of equality of distribution could be rejected for three of the independent variables. Table 5.2, below, is a summary of the statistical test results.

The over-all conclusions from this analysis of non-response data are that it is possible that 1) females were slightly more likely to respond to the questionnaire, as were 2) teachers from ethnically-diverse schools, and 3) teachers in religiously homogeneous (>50% Mormon or Catholic) counties. It will be necessary to look for possible influences of respondent gender, and the external social factors of student body ethnicity, and predominant county religion when analyzing questionnaire responses.
### Table 5.2: Results of Tests of Non-response Bias

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>test</th>
<th>p *</th>
<th>Conclusion (numbers in parentheses = percent that responded)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>( \chi^2 )</td>
<td>.024</td>
<td>Reject ( H_0 ); males (61%) were somewhat less likely to respond than females (70%)</td>
</tr>
<tr>
<td>Dominant student body ethnicity</td>
<td>( \chi^2 )</td>
<td>.012</td>
<td>Reject ( H_0 ); the few teachers (n=22 of 617) at schools with no dominant ethnic group were somewhat more likely to respond (96%) than those from primarily white (63%), Hispanic (62%), or Indian schools (70%)</td>
</tr>
<tr>
<td>Student socio-economic level (in percent receiving subsidized lunches)</td>
<td>( t )</td>
<td>.394</td>
<td>Fail-to-reject ( H_0 ); teachers from poor schools were no more or less likely to respond to the questionnaire than teachers from middle-income or wealthy schools</td>
</tr>
<tr>
<td>Size of school body (in 4 quartile categories)</td>
<td>( \chi^2 )</td>
<td>.093</td>
<td>Fail-to-reject ( H_0 ), although teachers at bigger schools may have been somewhat less likely to respond (63%) than those from small and medium schools (68%)</td>
</tr>
<tr>
<td>Community size (in 3 categories)</td>
<td>( \chi^2 )</td>
<td>.896</td>
<td>Fail-to-reject ( H_0 ); teachers in small towns or rural areas were just as likely to respond as teachers in urban schools</td>
</tr>
<tr>
<td>School type (regular, charter, private)</td>
<td>( \chi^2 )</td>
<td>.260</td>
<td>Fail-to-reject ( H_0 ); teachers at private or charter schools were no more or less likely to answer the questionnaire than were regular public school teachers</td>
</tr>
<tr>
<td>County</td>
<td>( \chi^2 )</td>
<td>.088</td>
<td>Fail-to-reject ( H_0 ), although teachers at large urban schools in Maricopa county (Phoenix metro area) were somewhat less likely to respond (61%) than teachers from either small, rural counties (67%) or those from Pima county, including the Tucson metro area (71%)</td>
</tr>
<tr>
<td>Dominant religion in county (&gt;50% Mormon, &gt;50% Catholic, and 25-50% Catholic)</td>
<td>( \chi^2 )</td>
<td>.013</td>
<td>Reject ( H_0 ); the relatively small numbers (&lt;40%) of teachers from predominantly Mormon or strongly Catholic counties were more likely to respond (74% and 71%, respectively) than teachers from religiously diverse counties (61%)</td>
</tr>
</tbody>
</table>

* p= the probability that the \( H_0 \) would be falsely rejected
The Questionnaire

Design

The questionnaire developed for this study was designed and tested initially in the context of a graduate seminar on the topic of questionnaire design offered by the University of Arizona College of Education in the fall of 1999. It was subsequently pilot-tested on instructors of Ecology and Evolutionary Biology at the University of Arizona, and several groups of high school biology teachers from the Tucson Unified School District, and was modified and revised several times.

The questions were arranged in a particular order, to gain the interest and cooperation of the participants, with easy behavior and opinion questions first, followed by the gathering of personal background information on the teachers. In the final version of the questionnaire (Appendix B), items 1-4 were designed to address Objective 1, described above, by measuring the amount of emphasis given evolution and creation, first with questions with Likert scales (Likert 1932), which are designed to measure attitudes at points along a continuum (e.g., no, little, moderate, strong emphasis) and then with questions asking for numbers of class periods devoted to each topic per semester. Item 5 asked for number of class periods devoted to human evolution. It was discovered after the questionnaire had been sent out that the scales for the questions asking teachers to specify numbers of class hours were improperly constructed, in that the answer choices were not discrete. These data can thus not be used without modification—e.g., dichotomization of the answer choices to < or > 7 class periods.

Items 6-16 were designed to address Objective 4, with a series of questions about
pressures and influences on their teaching of evolution by outside entities and individuals, using Likert-scaled answer choices (strong encouragement to strong discouragement).

Items 7-22 also addressed Objective 4, regarding the effects of the textbooks assigned to the teachers, and their outside reading habits. Some of these had dichotomous yes/no answer choices (17, 21), while others were opened-ended (22) or had Likert scales (18-20).

Items 23-38 were a series statements that addressed Objective 3, the opinions of teachers about the teaching of evolution and creation (23-25, 28-32, 38), and others that addressed Object 2, teacher knowledge of evolutionary theory and the nature of science (26, 27, 33-37). All have Likert scale answer choices (strongly agree to strongly disagree).

Objectives 5 and 6 (adequacy of teacher preparation, and willingness to improve their knowledge of evolutionary theory, respectively) were addressed by items 39-45. All but item 45 have Likert scale answer choices (strongly agree to strongly disagree); item 45 offers several options as well as an open-ended answer space.

The final goal specified above was to test hypotheses about relationships between dependent variables of teacher attitude and behavior in teaching evolution and/or creation and a series of independent demographic (or structural) variables: teacher knowledge, education level, specific training in biology, experience, gender, age, religious affiliation, etc. This was achieved using both bivariate and multivariate analyses, using data gathered in items 46-64.

Teachers were also encouraged to write any additional thoughts or comments on
the back of the questionnaire (a full page), which many did.

Validity

The validity of a measure is viewed as being "the extent to which the concept one wishes to measure is actually being measured by a particular scale or index" (Sirkin 1999: 73)—i.e., whether it actually measures what it purports to measure. There are several types of validity recognized for this type of research: face validity, content validity, criterion validity, and construct validity (Sirkin 1999). Face validity is established by approval of the instrument by recognized experts or individuals knowledgeable about the topic; content validity is also based to a certain extent on logic and expertise, addressing the degree to which all the generally-accepted meanings of the concept being tested are included in the measurement. Face and content validity of the instrument for the current study were established by interviews and pilot-testing conducted with a group of Tucson Unified School District high school biology teachers, as well as with instructors of Ecology and Evolutionary Biology at the University of Arizona. The questionnaire was seen as adequately addressing the teaching of evolution and creation. In addition, the face validity of the instrument was evaluated by an experienced educational professional, Dr. L. Aleamone, of the College of Education, University of Arizona, and tested by a large group of doctoral candidates in education. Revisions for clarity were made at that time, as were adjustments to the scales used in answer choices.

Two other types of validity, criterion validity and construct validity, were also considered. Criterion validity is the ability of a measurement to predict some criterion external to it—for example, an aptitude measure whose value could be tracked by
monitoring future behavior. This was considered to be outside the scope of the present study, which was designed to measure correlates for present behavior, not to predict future behavior. Finally, construct validity, the ability of a scale to measure variables that are theoretically related to the variable that the scale purports to measure (Sirkin 1999), was considered to have been achieved, based on a principal components analysis of the opinion items in the questionnaire (see Appendix C) that demonstrated a high degree of internal consistency.

The purpose of principal components analysis is to reduce the complexity of a large correlation matrix by accounting for the variance among variables in a linear fashion (Norusis 1990; Zegura 1978). The components themselves represent relationships between variables, and point to some underlying construct (e.g., an outlook or philosophy) that was not directly measured, but that is reflected in responses to the opinion questions; the construct itself must be identified by the researcher. The amount of variance explained, and thus extracted by the component is represented by its eigenvalue (which corresponds to the average number of variables needed to account for an equivalent amount of variation), and a statement of the percent of variance accounted for by the component. Each variable in the analysis (in this case, the opinion question) is given a coefficient, called a “loading” that represents the degree to which its variation is explained by the factor; the higher the loading, the better the explanation of variance.

Responses to the opinion questions fell into four components relating to 1) favor towards creationist views, 2) favor towards evolutionary theory, 3) general comfort with the topic of evolution, and 4) feelings about adequacy of preparation to teach evolution.
This clustering or grouping of responses explains 57% of the variation in responses, and is viewed as supporting the construct validity of the instrument—i.e., it shows that the questionnaire tapped some underlying constructs that hang together logically. It must be acknowledged, however, that a significant amount of variation is not explained by the principal components analysis.

**Reliability**

Reliability of a questionnaire refers to its freedom from measurement errors—i.e., whether it measures the same thing reliably, replicably. The questionnaire should be internally consistent, and its results should be replicable over intervals of time, e.g., through test-retest (Sirkin 1999). The above-mentioned principal components analysis (Appendix C) was seen as demonstrating the internal reliability of the instrument. The only measure of replicability of the instrument was shown in the 5 cases of respondents each submitting two copies of the questionnaire, no doubt responding to the second mailing which was sent out while their first completed questionnaire was in the mail, and constituting a kind of test-retest. In no case were there significant differences in the two sets of responses, although fervor of response varied somewhat—i.e., in no case was an "agree" changed to a "disagree", but in 12 instances a "strongly agree/disagree" became an "agree/disagree." It was therefore concluded that the reliability of the instrument had been established.

**Data Analysis**

Questionnaire responses were numerically coded and entered into an Excel spreadsheet. All data analyses were performed using SPSS version 10.0 for Windows.
Descriptive Objectives

The descriptive objectives listed above (description of the amount of emphasis given evolution and creation, the educational backgrounds of teachers, etc.) were best achieved through univariate analyses, e.g., the tabulation and presentation of simple frequencies.

Hypothesis Tests

Hypothesis testing of the relationships between ordinal dependent variables (teacher emphasis on evolution or creation, measured in two ways: a Likert scale of amount of emphasis, and an ordinal scale of numbers of hours per semester devoted to each topic) and a variety of independent variables (primarily teacher demographics, or structural variables), which are categorical, ordinal, and interval scale in nature, involved several different analytical tools. In most cases, bivariate relationships were sought via contingency tables, with attention paid to Goodman-Kruskal gamma statistic ($\gamma$) measures of ordinal association for ordinal variables (Goodman & Kruskal 1954), and Pearson’s contingency coefficients ($C$) for categorical variables.

Goodman-Kruskal gamma evaluates the net proportion of concordant pairs of observations, as compared with all pairs of observations in a contingency table of ordinal scale variables, and is computed as follows, where $P_s$ is the number of concordant pairs, and $P_d$ is the number of discordant pairs:

$$\gamma = \frac{P_s - P_d}{P_s + P_d}$$
Thus, the higher the $\gamma$ value, the stronger the relationship between the two variables. Gamma and its associated probability measure the proportional reduction in error of predicting the value of dependent variable based on the value of the independent variable—in essence, a correlation coefficient for ordinal variables. Gamma is also a directional measure, indicating the direction of the skew of data distribution in the contingency table.

Where one of the independent variables in the contingency table is categorical, the chi-square probability and associated contingency coefficient are most appropriate (Fielding & Gilbert 2000). Pearson's contingency coefficient ($C$) is a method of measuring associations between categorical variables for tables that exceed $2 \times 2$, and that utilizes the chi-square value but takes into account effects of sample size and degrees of freedom, and that restricts the values of the measure to between 0 and 1, like a Pearson's $r$. It is calculated as follows:

$$C = \sqrt{\frac{X^2}{X^2 + N}}$$

The principal components analysis that was performed using responses to the 19 opinion statements (items 23-41), described above, was used to create two attitude scores for each respondent. A creation attitude score was created using the four items with the highest loadings in component 1, and an evolution attitude score was creating using the
four items with the highest loadings in component 2 (see Appendix C). These scores were subsequently used in both bivariate and multivariate analyses as independent variables.

Additionally, once significant bivariate interactions had been identified, a series of regression models was assessed in the search for multivariate interactions. While the dependent variables of emphasis given evolution and emphasis given creation are ordinal in nature, and many of the independent variables are either ordinal or categorical, it is accepted practice in regression models to analyze the former as interval-level data when there are sufficiently large sample sizes, and the latter when they are dichotomized or recoded into dummy variables—with caveats regarding the interpretations (Fielding & Gilbert 2000; Hedderson & Fisher 1993; Sirkin 1999). Specifically, one cannot interpret a one-unit increase in an independent variable as indicating some specific quantitative increase in the dependent variable; the effect is more qualitative in nature.

The regressions performed were simple and multiple linear regressions, based on the standard regression formula: \( y = a + bx \), where \( y \) is the value of dependent variable, \( a \) is the \( y \)-axis intercept, \( b \) is the slope, and \( x \) is the value of the independent variable. In the multiple regression, the formula is modified to include the effects of several independent variables concurrently, and can be stated: \( y = a + b_1x_1 + b_2x_2 + b_3x_3 \ldots \)

Finally, a path analysis was performed for each dependent variable, using the regression coefficients generated during the regression analysis. Path analysis is an interesting visual presentation of direct and indirect effects of independent variables on the dependent variable (based on a causal relationship between independent variables),
where logical causal order can be established (Sapsford & Jupp 1996). It allows one to evaluate effects of independent variables on one another, as well as both directly and indirectly on the dependent variable. In the present study, it was presumed that religious beliefs and education both are causes of attitudes toward evolution and creation (rather than vice versa), and thus it was possible to construct a path diagram showing both the direct effects of education on emphasis given evolution, for example, and the indirect effects of education on emphasis via the conduit of attitude. In this example, the indirect effect of education on evolution emphasis is calculated as the product of direct effects (as measured by the regression coefficient) of education on the evolution attitude variable and the effect of evolution attitude on emphasis. The direct and indirect effects are then summed to give the overall effect of education on emphasis given evolution.

\[
\text{total effect of } V_{\text{indep}} \text{ on } V_{\text{dep}} = \\
\text{direct effect } V_{\text{indep}} \text{ on } V_{\text{dep}} + (\text{direct effect of } V_{\text{indep}} \text{ on } V_{\text{indep}} \times \text{effect of } V_{\text{indep}} \text{ on } V_{\text{dep}})
\]

As stated previously, all statistical analyses were performed using SPSS 10.0. Table 5.3, on the following page, displays the statistical tests performed for each of the hypothesis tests.
<table>
<thead>
<tr>
<th>Hypotheses (variable types*)</th>
<th>Statistical Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1A/2.1A: Emphasis on evolution/creation is related to highest degree achieved by teacher (O x O)</td>
<td>Ordinal correlations ($\chi^2$ and gamma statistics); multiple regressions</td>
</tr>
<tr>
<td>1.1B/2.1B: Emphasis on evolution/creation is related to possession of a degree in biological sciences (O x C)</td>
<td>Chi-square; simple and multiple regression</td>
</tr>
<tr>
<td>1.1C/2.1C: Emphasis on evolution/creation is related to amount of college coursework in evolutionary biology (O x O)</td>
<td>Ordinal correlations ($\chi^2$ and gamma statistics); multiple regressions</td>
</tr>
<tr>
<td>1.2/2.2: Emphasis on evolution/creation is related to teaching experience (O x O)</td>
<td>Ordinal correlations ($\chi^2$ and gamma statistics); multiple regressions</td>
</tr>
<tr>
<td>1.3/2.3: Emphasis on evolution/creation is related to amount of in-service training in the teaching of evolutionary theory (O x O)</td>
<td>Ordinal correlations ($\chi^2$ and gamma statistics); multiple regressions</td>
</tr>
<tr>
<td>1.4/2.4: Emphasis on evolution/creation is related to religious denomination (O x C)</td>
<td>Chi-square; simple and multiple regression</td>
</tr>
<tr>
<td>1.5/2.5: Emphasis on evolution/creation is related to religious fervor (O x O)</td>
<td>Ordinal correlations ($\chi^2$ and gamma statistics); multiple regressions</td>
</tr>
<tr>
<td>1.6/2.6: Emphasis on evolution/creation is related to teacher attitudes towards evolution (O x O &amp; I)</td>
<td>Ordinal correlations ($\chi^2$ and gamma statistics); multiple regressions</td>
</tr>
<tr>
<td>1.7/2.7: Emphasis on evolution/creation is related to teacher attitudes toward creation (O x O &amp; I)</td>
<td>Ordinal correlations ($\chi^2$ and gamma statistics); multiple regressions</td>
</tr>
<tr>
<td>1.8/2.8: Emphasis on evolution/creation is related to teacher gender (O x C)</td>
<td>Chi-square; simple and multiple regression</td>
</tr>
<tr>
<td>1.9/2.9: Emphasis on evolution/creation is related to teacher age (O x O)</td>
<td>Ordinal correlations ($\chi^2$ and gamma statistics); multiple regressions</td>
</tr>
<tr>
<td>1.10A/2.10A: Emphasis on evolution/creation is related to size of school (O x O)</td>
<td>Ordinal correlations ($\chi^2$ and gamma statistics); multiple regressions</td>
</tr>
<tr>
<td>1.10B/2.10B: Emphasis on evolution/creation is related to student ethnicity (O x C)</td>
<td>Chi-square; simple and multiple regression</td>
</tr>
<tr>
<td>1.10C/2.10C: Emphasis on evolution/creation is related to student socio-economic status (O x O)</td>
<td>Ordinal correlations ($\chi^2$ and gamma statistics); multiple regressions</td>
</tr>
<tr>
<td>1.120D/2.10D: Emphasis on evolution/creation is related to dominant religious denomination of community (O x C)</td>
<td>Chi-square; simple and multiple regression</td>
</tr>
</tbody>
</table>

* O = ordinal, C = categorical, I = interval
CHAPTER SIX
RESULTS OF THE ARIZONA BIOLOGY TEACHER SURVEY

Participant Demographics

Characteristics of Teachers:

The teachers were evenly divided by gender: 51% male and 49% female. The majority (61%) of teachers were in the 31-50 year range, 16% were under 30, and 22% were over 50 (item 60).

Figure 6.1: Age Distribution of Participants (%)

Teachers in the study had an average of 10.5 (s.d.=8.4) years of experience teaching biology, although the distribution is left-skewed--i.e., nearly half of the teachers had 7 or fewer years of experience.

Figure 6.2: Years Teaching by Participants (%)
In terms of religious affiliation, 28% percent of the teachers characterized themselves as mainstream Protestants, 27% as Catholic, 12% agnostic, 16% conservative Christians (including 6% Mormon), and 3% atheist; the remaining 14% was made up of people indicating that they were Jews, Muslims, Native Americans, Bahai, animists, existentialists, non-religious, and others—none of which constituted as much as 2% individually (item 61).

Forty-two percent considered religion to be "very important" in their lives, 39% "somewhat important", and 19% "unimportant" (item 62).
Teachers characterized their political philosophies as follows: 37% saw themselves as moderates, 28% as liberals, 25% as conservatives, 7% as apolitical, and 2% as radicals (item 64).

Characteristics of Schools

Ninety percent of the teachers taught at regular public schools, 7% at charter schools, and 3% at private schools. The median school body size was 1583 ($\bar{x} = 1516$).

![Figure 6.5: School Body Sizes (Quartiles)](image)

The majority of respondents (67%) came from schools in urban/suburban settings in either Pima or Maricopa Counties, with none of the other 13 counties individually accounting for as much as five percent of the sample.

The socio-economic status of students attending the schools of the respondent teachers was mostly (57%) moderately well-off to wealthy, defined as less than a third of student body receiving subsidized lunches. Twenty-six percent taught at schools where 34-55% of students received such subsidies (moderately poor), and 17% percent taught at schools where most (>55%) of the students received free lunches (poor).
The majority of teachers (62%) taught at schools that were predominantly white, as reported by the Arizona Board of Education. Another 26% taught at schools that had predominantly Hispanic student bodies, 7% at schools with predominantly Indian students, and 6% at schools with no dominant ethnicity—i.e., with no ethnic group making comprising as much as 50% of the student body.

Outside Influences on the Teaching of Evolution

When asked whether they felt encouraged, discouraged or uninfluenced by outsiders regarding the teaching of evolution, with few exceptions, the majority of participants reported being either encouraged or unaffected by outside individuals and
entities (items 6-14). The highest levels of discouragement were reported as coming from parents, students, and the teachers' own personal beliefs.

Most participants felt encouraged to teach evolution by the National Science Education Standards (56% encouraged, 42% not influenced), and by the Arizona State Board of Education (56% encouraged, 40% not influenced). Majorities reported being uninfluenced by local school boards (71%; 22% felt encouraged), the district science curriculum administrator (51%; 46% encouraged), their science department head (54%; 46% felt encouraged), other teachers (55%; 40% felt encouraged), parents (76%; felt 6% encouraged), and students (60%; 20% felt encouraged). The highest levels of discouragement were reported as coming from students (by 16% of the respondents), and parents (by 15% of the respondents).

In a space provided for write-in responses to the question of forces that encourage or discourage teachers from teaching evolution, of the 152 responses (36% of the participants), the most common entry (n=82) referred to the participants' personal beliefs and knowledge. Of those, the vast majority (89%) reported being encouraged by their own beliefs and knowledge; the remaining 11% were discouraged by personal beliefs. The next most common write-in (n=38) related to scientific evidence; again, a strong majority of these (92%) felt encouraged by scientific evidence, although three people reported being discouraged from teaching evolution by the scientific evidence available.

Only ten teachers reported being influenced by elements of the community outside the school, such as religious leaders or church members, and of these, 90% felt discouraged from teaching evolution by these forces.
Of the small group of teachers (n=4) who wrote in “time” as a factor influencing their decisions about teaching evolution, all reported a negative effect—i.e., the lack of time in the curriculum to devote many class periods to evolution.

When asked to rank these various outside forces in terms of the magnitude of influence, the factors most often ranked in the top four were the teacher’s own knowledge of evolutionary theory (65%, with 35% ranking it number one), the Arizona State Board of Education Curriculum Standards (53% ranked it in the top four, with 14% ranking it number one), the National Science Education Standards (49% ranked it in the top four, and 11% ranked it most important), and the textbooks they use (45% ranked it in the top four, and 7% ranked it most important). Other teachers, students, teachers’ own religious beliefs, and local school board policies were important influences for about a quarter of the teachers (25%, 24%, 23%, and 22%, respectively).

Unfortunately, the design of the question leaves out the element of direction—i.e., it is not possible to sort out whether these are negative or positive influences on teachers’ decisions regarding the teaching of evolution. Even reference back to the previous items (6-13) which did establish directionality was futile, since many teachers listed as top four influences entities that they had previously indicated as having no influence on their decision-making. Although this finding may seem to cast some doubt on the validity of the questionnaire, it is most likely that teachers were merely ranking a list of influences, without being cognizant of the positions they had already taken in earlier questions. Due to these problems, no further analysis was attempted with data from this section of the questionnaire.
Educational Characteristics of Teachers

Forty percent of Arizona high school biology teachers in the study had a bachelor’s degree only, although most of these also had some post-graduate course work. Fifty-five percent had a master’s degree, and another 5% reported having a doctorate of some type (item 46).

Figure 6.8: Educational Levels of Participants

A plurality of teachers (48%) attended one of Arizona’s three state universities (University of Arizona, Arizona State University, or Northern Arizona University). Another 14% attended state institutions in the nearby states of California, Colorado, New Mexico, Utah, or Texas. About five percent attended conservative Christian colleges such as Brigham Young in Utah, and Grand Canyon University in Arizona; another 4% attended Catholic, Methodist, Presbyterian, and other “liberal” Christian colleges. The remainder attended other state schools, liberal arts colleges, foreign universities, and institutions of unknown affiliation (see Figure 6.9, below).
Seventy-eight percent of the sample indicated that they have a degree in the biological sciences, while 18% said they had degrees in education, with the remaining 14% indicating degrees in other sciences, humanities, agriculture, etc. (item 47). One of my primary hypotheses involves the educational backgrounds of biology teachers—specifically, how much education in evolutionary biology teachers actually get, and how this correlates with their attitudes and behaviors regarding the teaching of evolution. It is therefore important to determine, as accurately as possible, the educational background of each teacher.

Since approximately half of the population of teachers in the study received degrees from one of Arizona's state universities (University of Arizona, Arizona State
University, or Northern Arizona University), it was therefore possible to do a 'degree check' with the registrar's offices of these universities, to verify the undergraduate major and minor of each graduate of these institutions in my study.

Some research determined that there was a fairly systematic over-estimation of the number of degrees in biological sciences; fewer than 60% of those indicating degrees in biological sciences actually had one. Of the 122 teachers indicating that they had received a degree in biological sciences from one of the state universities, I was able to obtain information on 79; of the 43 for whom no record was found, most were females, who may possibly have changed surnames after college due to marriage. Of the 79 for whom records were found, 70 claimed to have degrees in biological sciences, but only 40 (57%) actually did. As for the remaining 30 teachers who claimed a degree in biology, 17 (24% of the 70) had degrees in secondary education; additionally, 11 had degrees in agriculture, and 2 had other degrees outside of education or science, for a total of 19% of those claiming degrees in biological sciences.

Figure 6.11: Actual Degrees for Participants Claiming Degrees in Biology (%)

There is some variation by institution: 62% of those teachers with degrees from the University of Arizona, claiming to have degrees in biological science actually had one
(16 of 26); 38% of the Arizona State University graduates reported accurately (10 of 26); and 68% of graduates of Northern Arizona University who claimed degrees in biological sciences actually had them (17 of 25). In all cases, the majority of the erroneous reporters had degrees in secondary education, often with a minor or specialty in biology. While it may be understandable that people confuse a degree in teaching biology with an actual degree in the biological sciences, it is important to note that there are significant differences in the biology course requirements for a degree in biology, and a degree in secondary education with a specialty in biology (see Discussion).

The great majority (87%) reported completing more than 7 university courses in biology. In retrospect, this may not have been a very good question, because it asks respondents to recall details often from the distant past, affecting the reliability of the answers. Additionally, the answer choices did not discriminate well amongst the respondents. However, nearly one third (28%) of the teachers said that they had had no courses that explicitly addressed evolution (item 54), and half said they had had no coursework in human evolution (item 56).

![Figure 6.12: Number of Colleges Courses Taken that Explicitly Addressed Evolution](image-url)
Most (75%) had never had a class that explicitly addressed the evolution-creation debate (item 57), and two-thirds had had no subsequent in-service or post-graduate training in the teaching of evolution (item 58).

![Figure 6.13: Amount of In-Service Training in Evolutionary Theory](image)

Thus, while most teachers had taken many college biology courses, a significant number somehow missed any coursework that addressed the central explanatory framework of their discipline, most had no coursework in the evolution of their own species, and significant majorities have had neither coursework that addresses the evolution/creation debate nor any post-graduate training in teaching evolutionary theory.

**Role of Textbooks**

A strong majority (83%) of Arizona high school biology teachers said that they are part of the selection process for textbooks (item 17), but most also indicated that the coverage of evolution in their texts does not have a very strong influence on how they present the subject (item 18). A third of the teachers surveyed claimed that textbooks
had a significant influence on their coverage of evolution, while two-thirds stated that the
texts influence their coverage of evolution only "somewhat" or "not at all"; only 6% said
they relied completely on the text. Textbook content does not appear to be the main
factor determining teacher behavior on the topic of evolution.

The situation is similar for the effect of textbook coverage on the teaching of
human evolution: only 30% of teachers said that they rely very heavily on the texts to
determine their emphasis on the topic (item 19); a solid third (34%) indicated that they do
not rely on the text at all, despite the fact that the majority of texts give good coverage to
the topic of human evolution (item 20). What is unclear is whether the teachers who do
not follow the text are avoiding human evolution, despite the fact that it is covered in the
texts, or are bringing in outside resources.

**Teachers' Reading Habits**

About half (53%) of the teachers said that they were able to keep up with
publications on advances in biology (item 21). Thirty-eight percent said that in the last
three years they had read articles dealing with evolution in scientific or science-oriented
journals, such as *Science, Nature, Scientific American, Natural History, American
Biology Teacher*, or *National Geographic* (item 22). Seventeen percent said that they had
read such articles in popular sources such as newspapers, *Newsweek, Discover*, and *Time.*
Only 2% (n=8) listed creationist works, such as those by Duane Gish or Henry Morris of
the Institution for Creation Research, Philip Johnson of Berkeley Law School, Alvin
Plantinga of Notre Dame, or Michael Behe of Lehigh University.
Nearly half (43%) of the teachers could not (or did not) list anything that they had read in the last three years on the topic of evolution.

![Figure 6.14: Teacher Readings on Evolution (%)](image)

**The Modal Participant**

The “modal” participant in the study is therefore of either sex, 31-50 years old, with a master’s degree in biology education from an Arizona state university, and a little over 10 years of teaching experience. This teacher, while having taken over 7 university-level courses in biology, has had no coursework in human evolution and no class that explicitly addressed the evolution/creation debate, nor any in-service or post-graduate training in the teaching of evolution. He/she does not rely on classroom textbooks to determine coverage of evolution, feels up-to-date in the discipline of biology, has done some reading, on evolutionary theory in the past three years, but did not report having read anything in a scientific or educational journal in the last three years. This modal participant feels either mildly encouraged or uninfluenced by external pressures regarding the teaching of evolution, and is a self-reported mainstream Christian (Protestant or Catholic), moderately religious, politically moderate. He/she teaches at a public school in
Maricopa County, with an enrollment of about 1500, primarily white, moderately affluent students.

**Emphasis on Evolution**

Of the 419 Arizona high school biology teachers responding to the questionnaire, 96% said that they gave some emphasis to evolutionary theory (Table 6.1, below), although 11% also indicated that they spent no class periods on the topic (Table 6.2). I must conclude, then, that only 89% of Arizona high school biology teachers actually spend any time on evolution.

**Table 6.1: Responses to Item 1** (Please characterize the amount of emphasis you give the topic of evolution in the biology classes that you teach.) (N=418)

<table>
<thead>
<tr>
<th>Amount of emphasis</th>
<th>Percent response</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. No emphasis</td>
<td>3.6 (n=15)</td>
</tr>
<tr>
<td>B. Little emphasis</td>
<td>19.6 (n=82)</td>
</tr>
<tr>
<td>C. Moderate emphasis</td>
<td>44.6 (n=187)</td>
</tr>
<tr>
<td>D. Strong emphasis</td>
<td>32 (n=134)</td>
</tr>
</tbody>
</table>

It was recognized belatedly (i.e., after the questionnaire was sent out) that there was a serious error in the construction of the answer choices for questions 3-5, each of which asked teachers to specify the number of class periods in which certain topics were a major theme. Specifically, the answer choices are not discrete; there is overlap in answer choices that specify “1-3,” “3-5,” and “5-7.” While a case can be made that these still constitute ordinal scales, they may have provided difficulties for teachers who estimated that they spent exactly 3 or 5 class periods, and any analyses using these
variables much be approached, and interpreted with caution. The table and figure below present the responses to the item on class periods spent on evolution.

**Table 6.2: Responses to Item 3** (In how many class periods per semester is evolution a major theme?) (**N=418**)

<table>
<thead>
<tr>
<th>Number of class periods</th>
<th>Percent response</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. None</td>
<td>11 (n=46)</td>
</tr>
<tr>
<td>B. 1-3</td>
<td>24.3 (n=102)</td>
</tr>
<tr>
<td>C. 3-5</td>
<td>19.6 (n=82)</td>
</tr>
<tr>
<td>D. 5-7</td>
<td>12.9 (n=54)</td>
</tr>
<tr>
<td>E. &gt;7</td>
<td>32 (n=134)</td>
</tr>
</tbody>
</table>

Thus, thirty-five percent of Arizona teachers in this study indicated that they spent 3 or fewer class periods with evolution as a major theme (see Figure 6.15, below).

![Figure 6.15: Number of Class Periods in Which Evolution is a Major Theme (%)](image)

A chi-square test run on emphasis given evolution (Table 6.3, below) versus number of class periods in which evolution is a major theme, gave a significant result, as would be expected ($\chi^2=252.8$ with df=12, $p=.001$).
Table 6.3. Correlation of teacher characterization of emphasis given evolution and number of class periods devoted to it (numbers indicate counts; N=418)

<table>
<thead>
<tr>
<th>Emphasis on evolution</th>
<th>Number of class periods devoted to evolution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>none</td>
</tr>
<tr>
<td>No emphasis</td>
<td>13</td>
</tr>
<tr>
<td>(expected count)</td>
<td>(1.7)</td>
</tr>
<tr>
<td>Little emphasis</td>
<td>26</td>
</tr>
<tr>
<td>(expected count)</td>
<td>(9)</td>
</tr>
<tr>
<td>Moderate emphasis</td>
<td>7</td>
</tr>
<tr>
<td>(expected count)</td>
<td>(20.6)</td>
</tr>
<tr>
<td>Strong emphasis</td>
<td>0</td>
</tr>
<tr>
<td>(expected count)</td>
<td>(14.7)</td>
</tr>
</tbody>
</table>

$\chi^2 = 252.8$  \hspace{1cm} df=12  \hspace{1cm} p = <.001  \hspace{1cm} Spearman's r = 0.618

However, one variable explained only 38% of the variation in the other (Spearman's $r = 0.618$). This demonstrates that teachers interpreted the terms "no", "little", "moderate", and "strong" inconsistently; some felt that 3-5 class periods constituted little emphasis, while others considered that to be strong emphasis. The poorly constructed answer scale for item 3 may also be part of the explanation. It will therefore be necessary in bivariate and multivariate analyses involving the dependent variable of amount of emphasis given evolution to evaluate separately responses to item 3 (actual numbers of hours spent teaching evolution) as well as answers to item 1 (Likert-scale amount of emphasis given). This also points out potential weaknesses in studies that rely on subjective terminology, although it is possible to ameliorate this somewhat by carefully defining such terms (Aguillard 1998).
Despite answer scale problems, some information can be extracted from responses to item 5. Human evolution did not seem to be a topic covered in all high school biology classes—not surprising, since it is often the most potentially volatile of evolutionary topics. Although 64% of Arizona high school biology teachers said that they address human evolution, only 23% spent 3 or more class periods on it.

![Figure 6.16: Number of Class Periods Devoted to Human Evolution (%)](image)

Thus, one-third of Arizona high school students get no exposure to the evolution of their own species; another one-third get only a taste. A shortcoming of the present study is that it did not ask the reason for this; teachers may feel that human evolution is not as important as other aspects of biology, or may not have time to cover a topic that is not stressed in the State standards. However, it is clear from answers to the opinion questions, discussed in greater detail in a later section of this chapter, that although a strong majority (85%) of the teachers believed human evolution to be an appropriate topic for high school students (item 32), nearly half did not feel comfortable teaching human evolution (item 38), and a strong majority (80%) wanted to improve their own knowledge.
of the subject (item 44). It may be that greater education in human evolution would both increase the comfort level teachers feel with this topic, and increase the amount of classroom time they devote to it.

**Bi-variate Predictors of Emphasis on Evolution:**

As described in the previous chapter, a series of contingency tables was constructed in order to search for relationships between the dependent variable of emphasis given evolution and various independent variables, consisting of characteristics of teachers. This analysis was performed using both forms of the dependent variable—one that asked teachers to characterize, using a Likert scale, the amount of emphasis they gave evolution (item 1), and the other that indicated actual number of class hours spent on evolution (item 3).

The two versions of the dependent variable are both ordinal. The independent variables are either ordinal or categorical. In the case of a contingency table for two ordinal variables, the most meaningful statistics are the Goodman-Kruskal gamma statistic ($\gamma$) and its associated probability, which measure the proportional reduction in error of predicting the value of dependent variable based on the value of the independent variable—in essence, a correlation coefficient for ordinal variables. Gamma is also a directional measure, indicating the direction of the skew of data distribution in the contingency table. Where one of the independent variables in the contingency table is categorical, the chi-square probability and associated contingency coefficient are most appropriate (Fielding & Gilbert 2000). Relationships between the ordinal dependent variables and categorical independent variables were sought via chi-squares and
associated contingency coefficients. Presented in the tables, below, are summaries of significant or interesting results of these tests.

Despite the answer scale problems associated with the questions measuring numbers of class hour devoted to various topics, analyses were performed using item 3 and the teacher demographic variables. The results differed very little from those generated using the Likert scale measure of emphasis on evolution, and are displayed in table 6.5.
Table 6.4: Bivariate relationships between teacher demographic variables and amount of emphasis given evolution (in all cases, scales run from low to high values)

<table>
<thead>
<tr>
<th>Independent Variable (type*)</th>
<th>Chi-square</th>
<th>df</th>
<th>Effect Size</th>
<th>Sig. (p)</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational Level (O)</td>
<td>14.74</td>
<td>6</td>
<td>.095</td>
<td>.231</td>
<td>More education does not lead to more emphasis on evolution</td>
</tr>
<tr>
<td>Area of Reported Bachelor's Degree (C)</td>
<td>9.04</td>
<td>6</td>
<td>.146</td>
<td>.171</td>
<td>A major in biology does not lead to more emphasis on evolution</td>
</tr>
<tr>
<td>Area of Verified Bachelor's Degree (C)</td>
<td>1.45</td>
<td>6</td>
<td>.134</td>
<td>.962</td>
<td>Even when degrees in bio science could be verified, no relationship could be found with amount of emphasis given evolution</td>
</tr>
<tr>
<td>BA Institution (C)</td>
<td>10.03</td>
<td>6</td>
<td>.155</td>
<td>.018</td>
<td>Teachers from Christian colleges tend to de-emphasize evolution (only 60% give moderate-strong emphasis, compared to 80% of teachers from other types of colleges)</td>
</tr>
<tr>
<td>Years teaching (O)</td>
<td>22.41</td>
<td>9</td>
<td>.231</td>
<td>&lt;.001</td>
<td>Teachers with more experience emphasize more (36% of teachers with less than 5 years experience give little-or-no emphasis to evolution, compared with 18% of teachers with 5 or more years experience)</td>
</tr>
<tr>
<td>Number of college biology classes (O)</td>
<td>11.34</td>
<td>9</td>
<td>.291</td>
<td>.012</td>
<td>Teachers with more college coursework in biology emphasize more (68% of those with fewer than 7 college classes gave evolution moderate-to-strong emphasis, compared with 80% of those with more than 7 classes)</td>
</tr>
<tr>
<td>Number of college classes that addressed evolution explicitly (O)</td>
<td>45.83</td>
<td>9</td>
<td>.434</td>
<td>&lt;.001</td>
<td>More exposure to evolutionary theory in college results in more emphasis (73% of those who had taken 3 or fewer classes in college that explicitly addressed evolutionary theory gave the topic moderate-to-strong emphasis in the classes they taught, compared with 93% of teachers who had taken &gt;7 such classes)</td>
</tr>
<tr>
<td>Had in-service training in the teaching of evolution? (C)</td>
<td>11.34</td>
<td>6</td>
<td>.185</td>
<td>.01</td>
<td>Teachers with such training emphasize evolution more (73% of teachers who had had no in-service training gave evolution moderate-to-strong emphasis, compared with 85% of those who had had some training)</td>
</tr>
<tr>
<td>Age (in categories, O)</td>
<td>12.61</td>
<td>9</td>
<td>.127</td>
<td>.038</td>
<td>Younger teachers tend to de-emphasize (64% of teachers under 30 gave evolution moderate-to-strong emphasis, compared with 80% of older teachers)</td>
</tr>
<tr>
<td>Importance of religion (O)</td>
<td>45.08</td>
<td>6</td>
<td>-.396</td>
<td>&lt;.001</td>
<td>Increasing religiosity is related to decreasing emphasis (68% of those reporting that religion was very important in their lives gave evolution moderate-strong emphasis, compared with 84% of those not so religious)</td>
</tr>
<tr>
<td>Religious affiliation (C)</td>
<td>55.25</td>
<td>9</td>
<td>.346</td>
<td>&lt;.001</td>
<td>Those who self-identify as conservative Christians are much less likely to emphasize than non-Christians and non-religious teachers (only 59% of conservative Christians gave evolution strong-to-moderate emphasis, compared to 81% of all others)</td>
</tr>
</tbody>
</table>

* O=Ordinal; C=Categorical
1Gamma (γ); 2Contingency Coefficient(C)
Table 6.5: Bivariate relationships between teacher demographic variables and number of class periods in which evolution is a major theme (all scales from low to high)

<table>
<thead>
<tr>
<th>Independent Variable (type*)</th>
<th>Chi-square</th>
<th>df</th>
<th>Effect Size</th>
<th>Sig. (p)</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational Level (O)</td>
<td>11.43</td>
<td>8</td>
<td>.098</td>
<td>.159</td>
<td>More education does not lead to more emphasis+</td>
</tr>
<tr>
<td>Area of bachelors degree (C)</td>
<td>9.18</td>
<td>8</td>
<td>.147</td>
<td>.327</td>
<td>A major in biology does not lead to more emphasis+</td>
</tr>
<tr>
<td>Confirmed area of bachelors degree</td>
<td>4.04</td>
<td>8</td>
<td>.220</td>
<td>.854</td>
<td>No relationship between area of degree and emphasis on evolution+</td>
</tr>
<tr>
<td>BA institution (C)</td>
<td>12.16</td>
<td>8</td>
<td>.118</td>
<td>.144</td>
<td>Attendance at secular vs religious college has no effect #</td>
</tr>
<tr>
<td>Years teaching (O)</td>
<td>15.20</td>
<td>12</td>
<td>.188</td>
<td>&lt;.001</td>
<td>Teachers with more experience emphasize more+</td>
</tr>
<tr>
<td>Number of college biology classes (O)</td>
<td>11.54</td>
<td>4</td>
<td>.325</td>
<td>.001</td>
<td>Teachers with more college coursework in biology emphasize more+</td>
</tr>
<tr>
<td>Number of college classes that addressed evolution explicitly (O)</td>
<td>33.99</td>
<td>12</td>
<td>.267</td>
<td>&lt;.001</td>
<td>More exposure to evolutionary theory in college results in more emphasis+</td>
</tr>
<tr>
<td>Had in-service training in the teaching of evolution? (C)</td>
<td>18.68</td>
<td>6</td>
<td>.208</td>
<td>.001</td>
<td>Teachers with such training emphasize evolution more+</td>
</tr>
<tr>
<td>Age (in categories, O)</td>
<td>27.29</td>
<td>16</td>
<td>.076</td>
<td>.153</td>
<td>Age is not related to emphasis #</td>
</tr>
<tr>
<td>Importance of religion (O)</td>
<td>25.60</td>
<td>8</td>
<td>-.157</td>
<td>.013</td>
<td>Increasing religiosity is related to decreasing emphasis+</td>
</tr>
<tr>
<td>Religious affiliation (C)</td>
<td>20.52</td>
<td>12</td>
<td>.219</td>
<td>.058</td>
<td>Those who self-identify as conservative Christians are less likely to emphasize than non-Christians and non-religious+</td>
</tr>
</tbody>
</table>

* O=Ordinal; C=Categorical

\(^1\text{Gamma (γ); }^2\text{Contingency Coefficient (C)}\)

At the 0.01 significance level, the emphasis given evolution based on the Likert
scale (‘none’, ‘little’, ‘moderate’, ‘strong’) correlated positively with number of years teaching biology, the number of college biology classes taken that explicitly addressed evolution, and the amount of in-service training in teaching evolutionary theory.

Emphasis given to evolution correlated negatively with the importance of religion in the teacher’s life, and with a Conservative Christian religious affiliation. In simple frequencies, Conservative Christians were twice as likely to de-emphasize evolution (indicating little or no emphasis) as the general teacher population, and those indicating that religion was very important were 50% more likely to de-emphasize evolution (32% vs 20% of the general population).

At the 0.05 significance level, a positive relationship with emphasis on evolution can additionally be seen for attendance at a secular college or university, the number of college biology classes taken, and the age of the respondent.

No other independent variable, such as gender, personal politics, school size or type, socio-economic status or ethnicity of students, location in the state, or dominant community religion (e.g., Mormon) had any affect on the dependent variable. The most important influences on emphasis given evolution, as indicated by the magnitude of the coefficients of association (the $\gamma$ and $C$ values) are, in order of importance: number of college classes taken that explicitly address evolution, religious fervor, and religious affiliation. Since the measures of association hover around 0.4 for all these variables, each of them alone can explain only about 15% of the variation in the amount of emphasis given evolution.

Most interestingly, neither the possession of an advanced degree, nor a degree in
biological sciences was related to emphasis given evolution by a teacher. This conclusion was even stronger when the analysis was run using only those cases where the claim of having a degree in biological sciences was confirmed. The major effect of education, then, seems to be related to the magnitude of exposure to explicit information about evolutionary theory, rather than biology in general, or increased education in general.

Despite potential problems with answer scale, a repeat run with the same independent variables against the other form of the dependent variable (i.e., emphasis on evolution as measured by numbers of class periods devoted to the topic) gave much the same result. The only differences were the loss of a relationship between emphasis on evolution and 1) type of college attended, and 2) age of respondent. We cannot conclude, therefore that attendance at a religious college, or age of the teacher has any impact on the emphasis given evolution in the classroom. Additionally, the relationship between emphasis on evolution and religious affiliation was weakened from a significance of <.001 to 0.05, and the importance of religion in the respondent’s life from <.001 to 0.013. Nonetheless, these variables apparently are related to teacher classroom practice.

What seems clear from both sets of analyses is that an educational background with greater exposure to evolutionary theory is the best predictor of strong emphasis on evolution in the classroom. Simply having a degree in biological sciences has no impact. One the other hand, a high degree of religious fervor, and perhaps membership in a Conservative Christian denomination are the best predictors of low emphasis on evolution.
Attitudes Toward Evolutionary Theory

A series of statements was presented to the participants in the study to gauge their attitudes towards evolution and creation via their level of agreement or disagreement (items 23-41). A principal components analysis of the responses to these revealed that the underlying structure of the questionnaire can be described by the following components: favor towards creation, favor towards evolution, discomfort with human evolution, and feelings of professional inadequacy in teaching evolution. Favor towards creation alone explained the bulk (36%) of the variation in responses to the opinion questions, and the four components together explained 58% of the variation (see Appendix C); 42% thus remains unexplained. The four opinion items with the highest component coefficients (or loadings)—that is, those items best explained by the component—in the first two components (favor towards creation and favor towards evolution) could therefore be used to create creation and evolution opinion scores. These in turn were used to characterize a teacher's overall attitudes toward evolution and creation, and to search for relationships between attitudes, behaviors, and demographic features of teachers.

A very strong majority of the respondents agreed that evolution is an important unifying concept in biology (88%), and that it should be taught as part of high school biology classes (93%). Most also thought that evolution is a controversial topic to the general public (75%), but that it has a valid scientific foundation (90%). The majority reported believing that it is possible to be religious and still accept evolutionary theory (92%), and most did not feel personally conflicted teaching it (84%) nor did they avoid
using the word ‘evolution’ (86%).

There was an interesting low level of rejection of evolution, however. Around 10% of the teachers surveyed did not think that evolutionary theory was central to biology, nor important to the classes that they teach. Almost a quarter (23%) did not believe that the fossil record supports evolutionary theory, and 17% avowed that there is scientific evidence that disproves evolution (another 14% were uncertain). A significant number (22%) of the teachers disagreed that humans have evolved from ape-like ancestors, 10% rejected the notion that humans have been subject to the same evolutionary forces as other organisms, and 12% did not think human evolution was an appropriate topic for high school students. It is not surprising, then, that nearly half (43%) of the respondents reported feeling less comfortable teaching the evolution of humans than that of other organisms.

About 80% of the teachers expressed interest in increasing their knowledge of evolutionary theory, although most (53%) were unaware of opportunities to do so. When asked about their willingness to participate in a variety of activities to improve their knowledge of evolution, the most popular choices were reading on their own (74%), attending a workshop (72%), and taking a university course (47%). The latter choice would no doubt be a hardship for anyone not living close to Tucson, Phoenix, or Flagstaff. When asked to specify other ways to improve their knowledge, teachers also expressed interest in doing fieldwork, research on the web, and watching films on video.

**Relationships Between Teacher Attitudes and Emphasis on Evolution**

One might suppose that teacher emphasis on evolution in the classroom is related
to the opinions that teachers hold towards evolutionary theory—i.e., its scientific validity, its role in the study of biology, its ability to explain the fossil record and the relationships between humans and other organisms. Teacher emphasis on evolution may also be related to perceived conflicts in the minds of individual teachers between evolutionary theory and particular religious beliefs, particularly after a negative relationship was established in the previous section between teacher emphasis on evolution and self-identification as Conservative Christian or degree of religious fervor. A comparison of responses to the dependent variable of emphasis on evolution (in either of its two permutations, the Likert scale question, and the somewhat problematic number of class periods question) and responses to opinion statements, is thus in order.

**Bivariate Relationships Between Teacher Attitude and Behavior**

In order to verify that this was indeed the case, a series of contingency tables was performed (generating chi-squares, Goodman-Kruskal gamma statistics for ordinal relationships and directional measures) with each of the opinion questions against emphasis on evolution and creation. The results, not surprisingly, show significant relationships between the opinions of teachers and their classroom behaviors. This relationship held whether the amount of emphasis was measured by the Likert scale (items 1 and 2) or by the number of class periods spent on each topic (items 3 and 4).

Specifically, all of the opinion questions had significant relationships at the 0.05 significance level with the Likert scale emphasis given evolution, most with the gamma ($\gamma$) statistic measure of ordinal relationship in the .5 to .7 range (see Table 6.6, below).
Table 6.6: Relationships between opinion items and emphasis on evolution
(Likert scales, in all cases running from most negative to most positive)

<table>
<thead>
<tr>
<th>Item (see Appendix B for full text of opinion statements)</th>
<th>chi-square</th>
<th>df</th>
<th>sig. (p)</th>
<th>Gamma (γ)*</th>
<th>sig. (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q23: evolution should be taught</td>
<td>193.338</td>
<td>12</td>
<td>&lt;.001</td>
<td>.677</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q24: creation should be taught</td>
<td>90.290</td>
<td>12</td>
<td>&lt;.001</td>
<td>-.450</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q25: evolution is controversial</td>
<td>16.600</td>
<td>12</td>
<td>.165</td>
<td>-.148</td>
<td>.024</td>
</tr>
<tr>
<td>Q26: evolution is scientifically valid</td>
<td>143.241</td>
<td>12</td>
<td>&lt;.001</td>
<td>.609</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q27: creation is scientifically valid</td>
<td>113.127</td>
<td>12</td>
<td>&lt;.001</td>
<td>-.603</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q28: possible to be religious and accept evolution</td>
<td>83.546</td>
<td>12</td>
<td>&lt;.001</td>
<td>.261</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q29: I feel conflicted about teaching evolution</td>
<td>70.978</td>
<td>12</td>
<td>&lt;.001</td>
<td>-.509</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q30: I would like to teach creation</td>
<td>87.763</td>
<td>12</td>
<td>&lt;.001</td>
<td>-.515</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q31: evolution is not relevant to classes I teach</td>
<td>283.758</td>
<td>12</td>
<td>&lt;.001</td>
<td>-.771</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q32: human evolution is not appropriate for high school</td>
<td>107.424</td>
<td>12</td>
<td>&lt;.001</td>
<td>-.563</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q33: there is scientific evidence that disproves evolutionary theory</td>
<td>112.734</td>
<td>12</td>
<td>&lt;.001</td>
<td>-.562</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q34: evolution is important unifying concept in biology</td>
<td>185.658</td>
<td>12</td>
<td>&lt;.001</td>
<td>.619</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q35: fossil evidence too fragmentary to support evolution</td>
<td>141.951</td>
<td>12</td>
<td>&lt;.001</td>
<td>-.675</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q36: humans evolved from ape-like ancestor, beginning mya</td>
<td>120.468</td>
<td>12</td>
<td>&lt;.001</td>
<td>.279</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q37: humans are subject same evolutionary forces as other organisms</td>
<td>141.185</td>
<td>12</td>
<td>&lt;.001</td>
<td>.527</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q38: I feel less comfortable teaching human evolution</td>
<td>86.585</td>
<td>12</td>
<td>&lt;.001</td>
<td>-.421</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q39: my education is adequate</td>
<td>146.212</td>
<td>12</td>
<td>&lt;.001</td>
<td>.661</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q40: I avoid word ‘evolution’</td>
<td>193.570</td>
<td>12</td>
<td>&lt;.001</td>
<td>-.757</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q41: I am prepared for confrontation on topic of evolution</td>
<td>142.450</td>
<td>12</td>
<td>&lt;.001</td>
<td>.594</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

*Gamma is an ordinal, directional measure of relationship, analogous to Pearson’s r (see Methods)

The highest positive gamma values were for the statement "evolution should be taught as part of high school biology classes" (γ=.677), “my education has adequately
prepared my to teach evolutionary theory" (γ=.661), "evolution is an important unifying concept in biology" (γ=.619), and "the theory of evolution is scientifically valid" (γ=.609). The highest negative gammas were associated with the statements "I avoid using the word evolution" (γ= -0.757), "evolution is not relevant to the classes I teach" (γ= -0.771), "the fossil record is too fragmentary to be interpreted as supporting evolutionary theory" (γ= -0.675), and "creationism has a valid scientific foundation" (γ= -0.603). Thus, teachers who emphasize evolution accept its scientific validity, accept biological evolution for humans, feel educationally prepared to teach evolution and are comfortable defending it when confronted. Those that de-emphasize evolutionary theory do not accept (or are unaware of) its scientific validity or centrality to biology, feel uncomfortable with their level of preparation, tend to avoid the word 'evolution', and are uneasy about the topic of human evolution.

As discussed, although the answer scale was improperly constructed in item 3 (number of class periods devoted to evolution), the data could still be viewed as essentially ordinal, and exploratory analyses were performed using them.

Only one item became non-significant when number of class periods devoted to evolution was used as the dependent variable instead of the Likert scale item: the statement about the controversial nature of evolutionary theory in the eyes of the public (γ= -0.036). This is not a surprising finding, considering the question is about the teacher's perception of public opinion, not the opinion of the teacher.

Most of these cross-tabulations involved 4-by-4 tables (4 ordinal emphasis
categories by 4 ordinal opinion categories) or 4-by 5-tables (5 ordinal class period
categories by 4 ordinal opinion categories). Even with over 400 cases, some of the cells
were sparsely populated due to low frequencies of some responses, prompting a warning
from the statistical computer program regarding the validity of the test—i.e., that some
percentage of the cells had fewer than five cases, the arbitrary minimum number set by
SPSS. The low distribution of cases into some cells would seem to be the most
illuminating aspect of the data. However, in order to address any questions of the validity
of the findings, the cross-tabulations were also run on data collapsed into fewer
categories, such that the Likert scale characterizations of emphasis on evolution or
creation were recast as binary ('little or none' and 'moderate to strong'), the class periods
were collapsed (into '3 or fewer', '4-7' or '>7), and the opinion responses were reduced
to a dichotomous 'agree' or 'disagree'. While this obscured some important variation in
the data by reducing ordinal data to categorical data, it did get rid of the under-populated
cells. Additionally, it did not change the outcome: all opinion statements had significant
relationships with emphasis on evolution at the 0.05 confidence interval, and with gamma
values in the 0.2-0.4 range.

It is therefore concluded that all analyses confirm that teacher opinion is related to
teacher behavior of emphasizing or de-emphasizing evolution in the classroom. Teachers
who think that evolutionary theory is an important part of the biology classes that they
teach, who feel well-prepared educationally to teach evolutionary theory, and who accept
the theory as scientifically valid, emphasize evolution to a greater degree. Those who
think that evolutionary theory is not relevant to the biology classes that they teach, who
reject well-accepted scientific evidence for evolution, and who attribute scientific validity
to the theory of creationism, tend to de-emphasize evolution.

**Multivariate Predictors of Teacher Emphasis on Evolution: Regression Models**

In order to search for multivariate predictors of emphasis on evolution, and for
further hypothesis testing, a standard multiple regression analysis was performed between
the dependent variable of emphasis on evolution and the demographic variables with the
most significant correlations, as determined in the previous section. The non-significant
variables of gender and subject area of bachelor's degree were also added for hypothesis-
testing purposes. In total, regression equations were generated for the control variable of
gender; three educational variables (years teaching, number of courses taken that
explicitly addressed evolution, and possession of a degree in biological sciences); a
measure of the effects of religion based on denomination (using dummy variables for the
denominations of Catholic, conservative Christian, and liberal Protestant, with non-
religious as the reference category), and a measure of religious fervor; and an evolution
attitude score that was computed from responses to those four attitude questions with the
highest gamma values in correlations with teacher behavior (Table 6.6) and in the
principal components analysis (Appendix C)—items 23, 25, 34 and 37. Separate
regressions were performed for the control variable, educational influences, religious
influences, and attitudes. The final regression model incorporates all of the above
variables.

Table 6.7 displays the standardized regression coefficients (β) for each variable,
and intercepts and coefficients of determination (r²) for each model; it also provides the
regression coefficients for the same independent variables, using teachers' attitude
towards evolution as the dependent variable, for the purposes of comparison. That is, it is
possible to see the effects of various teachers' characteristics, including their attitudes, on
the amount of emphasis they give evolution; the second part of the table allows one to
compare those effects to the effects of the same independent variables on attitudes. The
ultimate goal is to parse effects on teacher behavior into direct effects and indirect effects
through attitudes. For those unaccustomed to reading regression analysis results in this
fashion, the intercept specified in the table is \( a \) (the y-axis intercept of the regression line
when \( x \) is zero), and the \( \beta \) coefficients are the regression coefficients for each
independent variable in the equation. This manner of presentation allows one to easily
compare effects and combinations of effects on the dependent variable. The \( r^2 \) value
allows one to gauge the proportion of the variation in the dependent variable that is
explained by each regression model.

The final regression equation for emphasis given by a teacher to evolution is

( using unstandardized regression coefficients):

\[
y (\text{emphasis on evolution}) = 0.635 + 0.014 \text{ (gender)} + 0.071 \text{ (years teaching)} + 0.190 \text{ (#college classes taken in evolutionary biology)} + 0.052 \text{ (degree in biology)} - 0.115 \text{ (Catholic)} + 0.002 \text{ (Conservative Christian)} + 0.097 \text{ (Liberal Protestant)} - 0.135 \text{ (religious fervor)} + 0.184 \text{ (evolution attitude score)}
\]
Table 6.7: Comparison of Factors Predicting the Emphasis Given Evolution and Attitudes Towards Evolution of Arizona High School Biology Teachers

Standardized Regression Coefficients (β) with associated probabilities (p)

<table>
<thead>
<tr>
<th>Dependent Variable: Emphasis on Evolution</th>
<th>Dependent Variable: Attitude Towards Evolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>Model 2</td>
</tr>
<tr>
<td>β</td>
<td>p</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Gender *</td>
<td>-0.058</td>
</tr>
<tr>
<td>Years teaching</td>
<td></td>
</tr>
<tr>
<td># college classes in evolutionary theory</td>
<td></td>
</tr>
<tr>
<td>Degree in biology**</td>
<td>-0.004</td>
</tr>
<tr>
<td>Catholic ‡</td>
<td></td>
</tr>
<tr>
<td>Conservative Christian ‡</td>
<td></td>
</tr>
<tr>
<td>Liberal Protestant ‡</td>
<td></td>
</tr>
<tr>
<td>Religious fervor</td>
<td></td>
</tr>
<tr>
<td>Evolution score</td>
<td></td>
</tr>
<tr>
<td>Model R²</td>
<td></td>
</tr>
</tbody>
</table>

* 1 = female  ** 1 = yes  ‡ reference denomination is non-religious
These results confirm earlier findings that gender and a degree in the biological sciences make no contribution to emphasis given evolutionary theory by a teacher. Amounts of teaching experience and college coursework that explicitly addressed evolutionary theory completed by the teacher contribute positively to emphasis on evolution in all of the regression models. When analyzed alone, religious fervor and membership in conservative Christian denominations also make significant negative contributions. However, when the evolution attitude score is added into the regression model, the religious variables become non-significant. This points to some kind of interaction between attitudes and conservative Christian membership in informing teacher behavior regarding the teaching of evolution. In order to further explore these interactions, a path analysis was performed, using the same standardized regression coefficients. Figure 6.17 (following page) visually represents that analysis.
Figure 6.17: Path Analysis of Factors Influencing Teacher Emphasis on Evolution
(using standardized regression coefficients)
The path analysis reinforces the conclusion that attitudes towards evolutionary theory make the largest direct contribution to teacher emphasis on evolution ($\beta=.429$)—far more than college coursework or teaching experience ($\beta=.303$ and $.153$, respectively). Additionally, the diagram shows that teaching experience and college coursework make minor ($\beta=.132$ and $.148$) contributions to teacher attitudes towards evolution, compared to the contributions made to those attitudes by religious fervor and membership in conservative Christian denominations ($\beta= -.304$ and -.332). These religious factors must then have significant indirect effects on teacher behavior through attitude.

It is also clear from the path analysis that the variables of religious fervor and membership in conservative Christian denominations make significant negative contributions to emphasis given evolution directly ($\beta= -.198$ and -.190). Additionally, the indirect effects of these two variables are of similar magnitude to the direct effects; together they explain a great deal ($\beta= -.328$ and -.332, respectively) of the variation in teacher emphasis given evolution.

**Emphasis on Creation**

Two items in the questionnaire asked respondents to characterize the amount of emphasis they give to religious explanations for the origins and diversity of life on earth (or creationism), one with a Likert-scale and the other with numbers of class periods per semester devoted to the topic. Problems with the latter scale have been discussed, and analysis using this variable is approached with caution.
Forty-six percent of Arizona high school biology teachers said that they gave no emphasis to creationism (item 2). A majority (54%) therefore did give some emphasis.

Figure 6.18: Amount of Emphasis Given Religious Explanations

Twenty-two percent of those spending some time on creation spent more than 3 class periods in which it was a major theme (item 4). Thus, the strong majority (78%) of the teachers indicating that creation is a part of their biology classes spent 3 or fewer class periods on the topic; unfortunately, the questionnaire did not distinguish those teachers who briefly mentioned the evolution/creation debate from those who presented creation as a competing scientific theory. We may interpret the findings as indicating that these teachers mentioned religious explanations, but apparently did not devote much time to them. This leaves 28% who did devote a significant amount of class time to this topic, although only 6% reported more than 3 class periods per semester in which religious explanations were a major theme.
As with the similar questions about emphasis given evolutionary theory, the correspondence between the Likert-scale emphasis given creation (item 2) and number of class periods spent on the topic (item 4) was only moderately strong: $\chi^2 = 221$ with $df=12, p=0<.001$, Pearson’s $r=.544$, $r^2=0.30$ (see Table 6.8, below). Again, it is recognized that the answer scales overlap. Nonetheless, much of the lack of correspondence between these two variables is explained, it seems, by the large number (n=104, a quarter of the sample) that reported spending no class periods on creation, but indicated that they gave “little emphasis” rather than “no emphasis” to the topic. There were also teachers who spent more than 7 class periods on creation, and felt that that constituted “little” or “moderate” emphasis, pointing out again the problem of the subjectivity of these terms.
Table 6.8: Correlation of teacher emphasis given creation and numbers of class periods devoted to it (numbers=counts; N=417)

<table>
<thead>
<tr>
<th>Emphasis on Creation</th>
<th>Class Periods in Which Creation is a Major Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>none (expected)</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>182</td>
</tr>
<tr>
<td></td>
<td>(138)</td>
</tr>
<tr>
<td>little (expected)</td>
<td>104</td>
</tr>
<tr>
<td></td>
<td>(120)</td>
</tr>
<tr>
<td>moderate (expected)</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>(35)</td>
</tr>
<tr>
<td>strong (expected)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(7)</td>
</tr>
</tbody>
</table>

χ²=221.1  df=12  p<.001  r=.544

Bivariate Predictors of Emphasis on Creation:

As with the emphasis on evolutionary theory variables, a series of contingency tables was used to search for relationships between the dependent variable of amount of emphasis given creation and the independent variables of teacher demographic features. Presented below, in Table 6.9, are the results of those investigations.
Table 6.9: Bivariate Relationships between teacher demographic variables and amount of emphasis given creation (in all cases, scales run from low to high values)

<table>
<thead>
<tr>
<th>Independent Variable (type)</th>
<th>Chi-square</th>
<th>df</th>
<th>Effect Size</th>
<th>Sig. (p)</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational Level (O)</td>
<td>7.82</td>
<td>6</td>
<td>-.084(^1)</td>
<td>.309</td>
<td>No relationship between education and emphasis on creation</td>
</tr>
<tr>
<td>Area of Reported Bachelors Degree (C)</td>
<td>5.45</td>
<td>6</td>
<td>.114(^1)</td>
<td>.488</td>
<td>A major in biology does not affect emphasis on creation</td>
</tr>
<tr>
<td>Area of Verified Bachelor's Degree (C)</td>
<td>6.01</td>
<td>6</td>
<td>.266(^2)</td>
<td>.422</td>
<td>Even when degrees in biology could be verified, no relationship to emphasis on creation</td>
</tr>
<tr>
<td>BA Institution (C)</td>
<td>2.29</td>
<td>3</td>
<td>.075(^2)</td>
<td>.515</td>
<td>Teachers from Christian colleges do not emphasize creation any more than those from secular institutions</td>
</tr>
<tr>
<td>Years teaching (O)</td>
<td>8.65</td>
<td>9</td>
<td>-.046(^1)</td>
<td>.454</td>
<td>Years teaching has no effect on emphasis on creation</td>
</tr>
<tr>
<td>Number of college biology classes (O)</td>
<td>5.17</td>
<td>9</td>
<td>-.018(^1)</td>
<td>.891</td>
<td>Amount of college coursework in biology has no effect on emphasis on creation</td>
</tr>
<tr>
<td>Number of college classes that addressed evolution explicitly (O)</td>
<td>15.23</td>
<td>9</td>
<td>.100(^1)</td>
<td>.161</td>
<td>More exposure to evolutionary theory has no effect on emphasis on creation</td>
</tr>
<tr>
<td>Had in-service training in the teaching of evolution? (C)</td>
<td>2.42</td>
<td>3</td>
<td>.076(^2)</td>
<td>.491</td>
<td>Such training does not affect emphasis on creation</td>
</tr>
<tr>
<td>Age (in categories, O)</td>
<td>7.42</td>
<td>12</td>
<td>-.031(^1)</td>
<td>.619</td>
<td>Age has no effect on emphasis given creation</td>
</tr>
<tr>
<td>Importance of religion (O)</td>
<td>29.06</td>
<td>6</td>
<td>.330(^1)</td>
<td>&lt;.001</td>
<td>Increasing religiosity is related to increasing emphasis (68% of those for whom religion is very important give some emphasis to creation, compared to 44% of those for whom religion is less important)</td>
</tr>
<tr>
<td>Religious affiliation (C)</td>
<td>24.55</td>
<td>9</td>
<td>.239(^2)</td>
<td>.004</td>
<td>Those who self-identify as conservative Christians are more likely to emphasize creation (71% give creation some emphasis, versus 49% of all others)</td>
</tr>
</tbody>
</table>

O=Ordinal; C=Categorical \(^1\)Gamma; \(^2\)Contingency Coefficient
No aspect of education or teaching experience seems to have had any significant relationship to the amount of emphasis teachers give to religious explanations of the origin and diversity of life on earth. Neither highest degree achieved, subject area of degrees, numbers of courses in biology or evolutionary biology, nor in-service training in the teaching of evolution had any affect. The only structural variables found to be related to the emphasis given to creationism in high school biology classes were religious fervor and religious denomination, such that increasing religious fervor and membership in Conservative Christian religious denominations were related to increasing emphasis on creation. Each had r-values around .230, demonstrating fairly weak relationships, although in simple frequencies, Conservative Christians were twice as likely to emphasize creation, compared to the total population of teachers. It may be recalled that in an earlier section, both of these variables were also negatively related to the amount of emphasis given evolutionary theory, and both with slightly higher r-values (.289 and .346, respectively). It would seem that other factors, or combinations of factors, yet to be identified, play a role in teacher emphasis on creation.

**Attitudes Towards Creationism**

Approximately one-third (32%) of the high school biology teachers surveyed agreed that creation should be taught in biology classes (item 24), a proportion similar to the approximately 28%, described above, who actually devoted a significant amount of class time to the topic.
Again, it is unclear whether those agreeing felt that creation should be taught as a scientific theory, as a philosophy, or as a social phenomenon. It also seems that the majority of Arizona biology teachers were more passionate about the inclusion of evolution than of creation (63% v. 8% answering in the "strongly agree" category). Additionally, only 25% of the respondents indicated that they wanted to teach creation themselves (item 30), leaving 7% who apparently want someone else to do it!

Nearly one-third (30%) of the participants did not reject the notion that creationism has a valid scientific foundation; 22% were certain of that foundation.
No other opinion questions directly addressed attitudes towards evolution. Based on these measures, it seems that just under one-third of Arizona high school biology teachers believed that creation should be taught as part of high school biology classes, would like to teach creation, and believed that creation has valid scientific support. The next section will present tests of relationship for attitudes towards evolution and creation, and emphasis given creation in the classroom.

**Relationships Between Teacher Attitudes and Emphasis on Creation**

As with the variables of emphasis on evolution, contingency tables revealed that teacher attitudes were strongly related to teacher behaviors in emphasizing creation in their classrooms. As presented in Table 6.10, below, nearly all of the opinion items had significant relationships with emphasis given creation.
Table 6.10: Bivariate Relationships between opinion items and emphasis on creation
(all variables with Likert scales, running from most negative to most positive)

<table>
<thead>
<tr>
<th>Item (see Appendix B for full text of statements)</th>
<th>chi-square</th>
<th>df</th>
<th>sig. (p)</th>
<th>Gamma (Y)</th>
<th>sig. (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q23: evolution should be taught</td>
<td>36.23</td>
<td>12</td>
<td>&lt;.001</td>
<td>-.245</td>
<td>.002</td>
</tr>
<tr>
<td>Q24: creation should be taught</td>
<td>209.23</td>
<td>12</td>
<td>&lt;.001</td>
<td>.668</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q25: evolution is controversial</td>
<td>13.12</td>
<td>12</td>
<td>.361</td>
<td>-.035</td>
<td>.636</td>
</tr>
<tr>
<td>Q26: evolution is scientifically valid</td>
<td>54.82</td>
<td>12</td>
<td>&lt;.001</td>
<td>-.366</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q27: creation is scientifically valid</td>
<td>109.07</td>
<td>12</td>
<td>&lt;.001</td>
<td>.438</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q28: possible to be religious and accept evolution</td>
<td>28.93</td>
<td>12</td>
<td>.004</td>
<td>.044</td>
<td>.582</td>
</tr>
<tr>
<td>Q29: I feel conflicted about teaching evolution</td>
<td>27.88</td>
<td>12</td>
<td>.007</td>
<td>.314</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q30: I would like to teach creation</td>
<td>143.67</td>
<td>12</td>
<td>&lt;.001</td>
<td>.634</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q31: evolution is not relevant to classes I teach</td>
<td>42.357</td>
<td>12</td>
<td>&lt;.001</td>
<td>.227</td>
<td>.002</td>
</tr>
<tr>
<td>Q32: human evolution is not appropriate for high school</td>
<td>13.76</td>
<td>12</td>
<td>.316</td>
<td>.073</td>
<td>.314</td>
</tr>
<tr>
<td>Q33: there is scientific evidence that disproves evolutionary theory</td>
<td>47.84</td>
<td>12</td>
<td>&lt;.001</td>
<td>.251</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q34: evolution is important unifying concept in biology</td>
<td>54.946</td>
<td>12</td>
<td>&lt;.001</td>
<td>-.347</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q35: fossil evidence too fragmentary to support evol.</td>
<td>67.71</td>
<td>12</td>
<td>&lt;.001</td>
<td>.310</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q36: humans evolved from ape-like ancestor, beginning mya</td>
<td>36.49</td>
<td>12</td>
<td>&lt;.001</td>
<td>-.247</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q37: humans are subject same evolutionary forces as other organisms</td>
<td>23.158</td>
<td>12</td>
<td>.020</td>
<td>-.271</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q38: I feel less comfortable teaching human evolution</td>
<td>29.180</td>
<td>12</td>
<td>.004</td>
<td>.030</td>
<td>.649</td>
</tr>
<tr>
<td>Q39: my education is adequate</td>
<td>19.365</td>
<td>12</td>
<td>.080</td>
<td>-.105</td>
<td>.130</td>
</tr>
<tr>
<td>Q40: I avoid word ‘evolution’</td>
<td>15.68</td>
<td>12</td>
<td>.206</td>
<td>.004</td>
<td>.957</td>
</tr>
<tr>
<td>Q41: I am prepared for confrontation on topic of evolution</td>
<td>19.262</td>
<td>12</td>
<td>.082</td>
<td>.046</td>
<td>.548</td>
</tr>
</tbody>
</table>

As with the previous analysis on emphasis given evolution, some variables that were significantly related to teacher emphasis on creation based simply on the chi-square
lose that significance when the fact that both variables are ordinal is taken into account (the gamma statistic).

At the 0.05 significance level (for the gamma statistic), most of the opinion items showed relationships to the Likert-scale teacher emphasis on creation, with the following exceptions: the statement on the public view of evolutionary theory as controversial (item 25), the statement that it is possible to be religious and still embrace evolutionary theory (item 28), the statement that human evolution is not an appropriate topic for high school students (item 32), and statements about teacher comfort levels (item 38), educational adequacy (item 39), avoidance of the word ‘evolution’ (item 40), and preparation to deal with confrontation regarding evolutionary theory (item 41). It would appear from this that the public view of evolution and teacher feelings of inadequacy in teaching evolution are not what are driving teacher emphasis on creation.

When the same analyses were performed using the other form of the dependent variable (emphasis on creation as measured by numbers of class periods per semester devoted to the topic), adequacy of educational background in evolutionary theory became significantly related ($\gamma = -0.166$, $p=0.047$). The other relationships remained the same, in both direction and intensity. Again, due to the problems with the construction of answer scale for this question, significance of the findings must be approached with caution.

Not surprisingly, the highest positive gamma values (in .4 to .7 range) for both sets of analyses were associated with the statement that creation should be taught as part of public school biology classes, the statement expressing personal desire to teach creation, and the belief that creationism has a valid scientific foundation. These results
appear to indicate that the strongest contributors to teacher decision-making about the amount of emphasis to devote to creation are beliefs that creation is a scientifically valid theory that should be taught in high school biology classes, and a person desire to teach it.

The highest negative gamma values (in the .2 to .4 range) were associated with the statements that evolution has a valid scientific foundation, and the two items associated with human evolution. These results seem to indicate that teachers who questioned the scientific validity of evolutionary theory, and who rejected evolution for humans, specifically, were more likely to emphasize creation to a greater degree. However, the magnitudes of these gamma values also indicate that these attitudes explain only half the variation in emphasis on creation that previous set of variables did. That is, belief in the scientific validity and appropriateness of creation to high school biology classes explained more of the variation in emphasis on creation than did doubts about evolution. It may be that belief in creation causes doubts about evolution, but the reverse is also possible, and the available data cannot be used to attribute causation.

**Multivariate Predictors of Teacher Emphasis on Creation: Regression Models**

In order to search for predictive relationships between multiple independent variables and the dependent variable of emphasis given creation, and for further hypothesis testing, a standard multiple regression analysis was performed using the same demographic variables used in the similar analyses for emphasis given evolution. These included features of experience and education that did not show significant correlation to emphasis given creation, but were included for comparative purposes. This was also the
case for the control variable of gender. Dummy variables were computed for Catholic, conservative Christian, and liberal Protestant religious denominations, with non-religious as the reference category. The final variable was the creation attitude score, the sum of scores from items that had the highest correlation coefficients and component loadings from the principal components analysis: items 24, 27, 30, and 35 (see Table 6.10 and Appendix C). Table 6.11 summarizes the results of those analyses.

The final regression equation for emphasis given by a teacher to creation is (using unstandardized regression coefficients):

\[
y \text{(emphasis on creation)} = 0.615 + 0.019 \text{ (gender)} + 0.013 \text{ (years teaching)} + 0.139 \text{ (#college classes taken in evolutionary biology)} - 0.012 \text{ (degree in biology)} - 0.064 \text{ (Catholic)} + 0.014 \text{ (Conservative Christian)} + 0.018 \text{ (Liberal Protestant)} + 0.067 \text{ (religious fervor)} + 0.123 \text{ (creation attitude score)}
\]
Table 6.11: Comparison of Factors Predicting the Emphasis Given Creation and Attitudes Towards Creation of Arizona High School Biology Teachers

Standardized Regression Coefficients (β) with associated probabilities (p)

<table>
<thead>
<tr>
<th>Dependent Variable: Emphasis on Creation</th>
<th>Dependent Variable: Attitude Towards Creation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>Model 2</td>
</tr>
<tr>
<td>β</td>
<td>p</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Gender *</td>
<td>-0.035</td>
</tr>
<tr>
<td>Years teaching</td>
<td>-0.027</td>
</tr>
<tr>
<td># college classes in evolutionary theory</td>
<td>0.100</td>
</tr>
<tr>
<td>Degree in biology**</td>
<td>0.016</td>
</tr>
<tr>
<td>Catholic ‡</td>
<td>0.127</td>
</tr>
<tr>
<td>Conservative</td>
<td>0.127</td>
</tr>
<tr>
<td>Christian ‡</td>
<td>0.008</td>
</tr>
<tr>
<td>Liberal Protestant ‡</td>
<td>-0.024</td>
</tr>
<tr>
<td>Religious fervor</td>
<td>0.173</td>
</tr>
<tr>
<td>Creation Score</td>
<td>0.481</td>
</tr>
<tr>
<td>Model r²</td>
<td>0.001</td>
</tr>
</tbody>
</table>

* 1= female  ** 1= yes  ‡ reference denomination is non-religious
As in the multiple regression analysis performed on the dependent variable of emphasis on evolution, neither gender nor a degree in biological sciences had any impact on the emphasis a teacher gave to creation in the classroom. Amount of teaching experience also had no effect on emphasis given creation; the reader may recall that this was not the case with emphasis on evolution, where greater teaching experience was positively related to teacher emphasis. In the case of creation, teaching experience has no patterned effect on emphasis given the topic. However, the number of college courses taken by the participant that explicitly addressed evolutionary theory was a positive predictor of emphasis given creation, just as it was for emphasis given evolution. To clarify, the more such college courses a teacher had taken, the more likely he/she was to emphasize creation—a finding that is a bit perplexing. Although the survey did not measure this, it is possible that teachers with stronger grounding in evolutionary theory recognize its potential conflict with creation stories, and are prepared to at least briefly compare the two theories. This is also the only variable that remains significant once the creation attitude score is entered into the regression equation. Something about college coursework, independent of attitudes towards creation, seems to contributing to emphasis given creation.

Membership in Conservative Christian denominations was a positive predictor of emphasis given creation, as was religious fervor, when analyzed by themselves, but when the creation attitude score was added into the regression equation, those relationships disappear. As with the regressions on emphasis on evolution, the creation attitude score was the greatest predictor of emphasis given creation, explaining nearly half of the
variation in the dependent variable ($\beta = .484$). This again points to some interaction between demographic features of participants, attitudes, and behaviors. To explore this possibility, a path analysis was performed on these variables, using standardized regression coefficients. The results are shown in Figure 6.22, on the following page.

One of the interesting findings of this analysis is that while teaching experience has a non-significant effect on the amount of emphasis a teacher gives creation, experience has a significant negative effect on teacher attitudes towards creation. Likewise, the positive effect of greater coursework in evolutionary theory on the amount of emphasis a teacher gives creation becomes a negative effect on teacher attitudes towards creation. This lends a bit of credence to the idea proposed earlier that experienced teachers, and teachers with stronger educational backgrounds in evolutionary theory may address the topic of creation, recognizing a potential source of conflict for students, but these teachers apparently do not present creation as a valid scientific theory, and hence have low creation attitude scores.

Summing the direct and indirect effects of the religious factors (Conservative Christian denomination and religious fervor), one sees the magnitude of their influence: $\beta = .244$ and $.313$, respectively. Attitude is the only variable with a larger effect on teacher behavior when it comes to emphasizing creation.
Figure 6.22: Path Analysis of Factors Influencing Teacher Emphasis on Creation
(using standardized regression coefficients)

- Years Teaching
- Course work in evolution
- Conservative Christian
- Religious fervor

Arrows indicate the direction of influence with regression coefficients as follows:

- Years Teaching: -0.100
- Course work in evolution: -0.112
- Conservative Christian: 0.244
- Religious fervor: 0.293
- Attitudes towards creation: 0.168
- Emphasis on Creation: 0.481

Non-significant regression coefficients indicated by dashed lines.
Summary of Hypothesis-Test Results:

Summarized in Tables 6.12 and 6.13, below, are the results of the hypothesis tests specified in Chapter 5 (Methods).

The characteristics of teachers and their environments that were positively related to teacher emphasis on evolution in the classroom were: 1) the amount of college coursework a teacher had done that explicitly addressed evolutionary theory, 2) the amount of teaching experience, 3) the amount of in-service training a teacher had in teaching evolution, and 4) positive attitude towards evolutionary theory.

The factors that related negatively to emphasis given evolution were: 1) degree of religious fervor, 2) membership in a conservative Christian religious denomination, and 3) positive attitude toward creation.

The characteristics of teachers and their environments that were positively related to teacher emphasis on creation in the classroom were: 1) religious fervor, 2) membership in a conservative Christian religious denomination, and 3) positive attitude toward creation.

Factors that related negatively to emphasis given creation were: 1) positive attitudes toward evolution, and school size.
Table 6.12: Summary of Evolution Hypothesis-Test Results

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Effect Size</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1A Emphasis on evolution is related to highest degree achieved by teacher</td>
<td>.095&lt;sup&gt;1&lt;/sup&gt;</td>
<td>No relationship</td>
</tr>
<tr>
<td>1.1B Emphasis on evolution is related to possession of a degree in biological sciences</td>
<td>-.004&lt;sup&gt;3&lt;/sup&gt;</td>
<td>No relationship</td>
</tr>
<tr>
<td>1.1C Emphasis on evolution is related to amount of college coursework in evolutionary biology</td>
<td>.303&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Positive relationship</td>
</tr>
<tr>
<td>1.2 Emphasis on evolution is related to teaching experience</td>
<td>.153&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Positive relationship</td>
</tr>
<tr>
<td>1.3 Emphasis on evolution is related to amount of in-service training</td>
<td>.178&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Positive relationship</td>
</tr>
<tr>
<td>1.4 Emphasis on evolution is related to religious denomination</td>
<td>.219&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Conservative Christians emphasize less than others</td>
</tr>
<tr>
<td>1.5 Emphasis on evolution is related to religious fervor</td>
<td>-.157&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Negative relationship</td>
</tr>
<tr>
<td>1.6 Emphasis on evolution is related to teacher attitudes towards evolution</td>
<td>.517&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Positive relationship</td>
</tr>
<tr>
<td>1.7 Emphasis on evolution is related to teacher attitudes toward creation</td>
<td>-.448&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Negative relationship</td>
</tr>
<tr>
<td>1.8 Emphasis on evolution is related to teacher gender</td>
<td>-.058&lt;sup&gt;3&lt;/sup&gt;</td>
<td>No relationship</td>
</tr>
<tr>
<td>1.9 Emphasis on evolution is related to teacher age</td>
<td>.076&lt;sup&gt;1&lt;/sup&gt;</td>
<td>No relationship</td>
</tr>
<tr>
<td>1.10A Emphasis on evolution is related to size of school</td>
<td>-.040&lt;sup&gt;3&lt;/sup&gt;</td>
<td>No relationship</td>
</tr>
<tr>
<td>1.10B Emphasis on evolution is related to student ethnicity</td>
<td>-.009&lt;sup&gt;2&lt;/sup&gt;</td>
<td>No relationship</td>
</tr>
<tr>
<td>1.10C Emphasis on evolution is related to student socio-economic status</td>
<td>-.001&lt;sup&gt;1&lt;/sup&gt;</td>
<td>No relationship</td>
</tr>
<tr>
<td>1.10D Emphasis on evolution is related to dominant religious denomination of community</td>
<td>.069&lt;sup&gt;4&lt;/sup&gt;</td>
<td>No relationship</td>
</tr>
</tbody>
</table>

<sup>1</sup>gamma; <sup>2</sup>contingency coefficient; <sup>3</sup>standardized regression coefficient
Table 6.13: Summary of Creation Hypothesis-Test Results

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Effect Size</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1A Emphasis on creation is related to highest degree achieved by teacher</td>
<td>-.084²</td>
<td>No relationship</td>
</tr>
<tr>
<td>2.1B Emphasis on creation is related to possession of a degree in biological sciences</td>
<td>-.058²</td>
<td>No relationship</td>
</tr>
<tr>
<td>2.1C Emphasis on creation is related to amount of college coursework in evolutionary biology</td>
<td>.100²</td>
<td>No relationship</td>
</tr>
<tr>
<td>2.2 Emphasis on creation is related to teaching experience</td>
<td>-.046²</td>
<td>No relationship</td>
</tr>
<tr>
<td>2.3 Emphasis on creation is related to amount of in-service training</td>
<td>.076¹</td>
<td>No relationship</td>
</tr>
<tr>
<td>2.4 Emphasis on creation is related to religious denomination</td>
<td>.239²</td>
<td>Conservative Christians are more likely than others to emphasize creation</td>
</tr>
<tr>
<td>2.5 Emphasis on creation is related to religious fervor</td>
<td>.330¹</td>
<td>Positive relationship</td>
</tr>
<tr>
<td>2.6 Emphasis on creation is related to teacher attitudes towards evolution</td>
<td>-.268²</td>
<td>Negative relationship</td>
</tr>
<tr>
<td>2.7 Emphasis on creation is related to teacher attitudes toward creation</td>
<td>.481²</td>
<td>Positive relationship</td>
</tr>
<tr>
<td>2.8 Emphasis on creation is related to teacher gender</td>
<td>-.035²</td>
<td>No relationship</td>
</tr>
<tr>
<td>2.9 Emphasis on creation is related to teacher age</td>
<td>-.031¹</td>
<td>No relationship</td>
</tr>
<tr>
<td>2.10A Emphasis on creation is related to size of school</td>
<td>-.111³</td>
<td>Teachers at smaller schools tend to emphasize more</td>
</tr>
<tr>
<td>2.10B Emphasis on creation is related to student ethnicity</td>
<td>.071²</td>
<td>No relationship</td>
</tr>
<tr>
<td>2.10C Emphasis on creation is related to student socio-economic status</td>
<td>.077¹</td>
<td>No relationship</td>
</tr>
<tr>
<td>2.10D Emphasis on creation is related to dominant religious denomination of community</td>
<td>.116²</td>
<td>No relationship</td>
</tr>
</tbody>
</table>

¹gamma; ²contingency coefficient; ³standardized regression coefficient
Evolution/Creation Interactions

A standard regression analysis was performed between the variables of emphasis given evolution and emphasis given creation by teachers in the classroom, with emphasis on evolution set arbitrarily as the dependent variable. This analyses showed no significant relationship between the two variables, with \( F = .274 \) (df = 1), \( p = .601 \), \( \beta = .026 \), and \( r^2 = .001 \).

A similar analysis was performed for evolution attitude score and creation attitude score, with creation score arbitrarily set as the dependent variable. This analysis revealed that the two attitude scores were negatively related to one another, with \( F = 129.86 \) (df=1), \( p < .001 \), \( \beta = -.492 \), \( r = .242 \).

Table 6.14, below, summarizes relationships between each of the emphasis variables (dependent) and each of the attitude scores (independent).

**Table 6.14: Summary of Relationships Between Attitudes and Emphasis Given Evolution and Creation**
*(Standardized Regression Coefficients)*

<table>
<thead>
<tr>
<th></th>
<th>Emphasis Given Evolution</th>
<th>Emphasis Given Creation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evolution Attitude Score</td>
<td>.517 ((r^2 = 0.268))</td>
<td>-.277 ((r^2 = 0.077))</td>
</tr>
<tr>
<td>Creation Attitude Score</td>
<td>-.449 ((r^2 = 0.200))</td>
<td>.481 ((r^2 = 0.232))</td>
</tr>
</tbody>
</table>

While attitudes toward evolution explained much of the variation in emphasis given evolution, they had little impact on the amount of emphasis given creation. Attitudes toward creation explained a significant proportion of the variation in emphasis given that topic, but also explained almost as much of the variation in emphasis given evolution.
That is, a high creation attitude score had almost as much negative effect on emphasis
given evolution as it had a positive effect on emphasis given creation. As mentioned
earlier, the two attitude scores are strongly related ($r^2 = .242$), but the two emphasis
variables are not ($r^2 = .001$). This points to some other factor contributing to the impact
of creation attitude on emphasis given evolution. This is almost certainly the major
contribution to creation attitude made by Conservative Christian religious fervor,
discussed in the previous section on path analysis.

The following chapter will summarize the survey results, and offer some
conclusions and recommendations.
CHAPTER SEVEN
SUMMARY, CONCLUSIONS, RECOMMENDATIONS

It will come as no surprise to the reader that I am a proponent of emphasizing evolutionary theory in high school biology classes; in fact, in my opinion such emphasis should come well before high school. One conclusion I draw from the results of my survey is that approximately one-third of Arizona’s biology teachers did not give evolution the emphasis it deserves as the central organizing principle of biology. Additionally, a significant minority (~15%) of these teachers characterized themselves as giving moderate-to-strong emphasis to religious explanations for the origins and diversity of life on earth—an activity that the United States Supreme Court has ruled unconstitutional. What follow are a series of summaries of the main findings of the survey regarding the causes of the above teacher practices, my thoughts on the significance of those findings, and some recommendations on how to address the issues of under-emphasis on evolution and over-emphasis on creation.

The Modal Participant

The “modal” participant in the study was equally likely to be male or female, 31-50 years old, with a master’s degree in biology education from an Arizona state university, and a little over 10 years of teaching experience. This teacher, while having taken over 7 university-level courses in biology and a couple of courses that explicitly addressed evolutionary theory, had no coursework in human evolution and no class that
explicitly addressed the evolution/creation debate, nor any in-service or post-graduate training in the teaching of evolution.

He/she did not rely on classroom textbooks to determine coverage of evolution, felt up-to-date in the discipline of biology, and had done some reading on evolutionary theory in the past three years, but nothing in a scientific or educational journal. This modal participant felt either encouraged or uninfluenced by external pressures regarding the teaching of evolution, and was a self-reported mainstream Christian (Protestant or Catholic), moderately religious, and politically moderate. He/she taught at a public school in Maricopa County (which includes the Phoenix metro area), with an enrollment of about 1500, primarily white, moderately affluent students.

While the modal participant is teaching evolutionary theory, many of the participants seem under-prepared in terms of their own educational backgrounds, particularly in specific evolutionary biology and human evolution coursework. Most had also not had any in-service training on teaching evolution, and reported that such means to improve their skill were unavailable, or unknown to them. Since such coursework correlated strongly with emphasis given evolutionary theory, a significant minority of the teachers in the study may not really be prepared to teach evolutionary theory or to adequately address confrontation on the topic. The specifics of these issues are discussed below.

**Emphasis Given Evolution**

Three-quarters of Arizona high school biology teachers said they gave moderate-to-strong emphasis to evolutionary theory in their classrooms, reporting an average of 3-5
class periods per semester in which evolution was a major theme (acknowledging, once again, that this answer scale was incorrectly constructed). Only one-third characterized themselves as giving evolution strong emphasis. This leaves a quarter of Arizona’s teachers that did not emphasize evolutionary theory, and a third who reported fewer than 3 class periods during a semester in which the primary organizing principle of their discipline is a major topic. More than ten percent left it out entirely. This is unacceptable, given the central role of evolutionary theory in the study of biology. It is therefore critical to make specific the factors (possibly causal) that are associated with teacher de-emphasis or omission of evolutionary theory.

Predictors of Emphasis on Evolution: Education and Teaching Experience

Few aspects of teacher background or school environment correlated with emphasis on evolution. Neither gender, nor age of teachers, nor size/ethnicity/dominant religion/economic composition of the student body had any relationship to the amount of emphasis teachers gave evolution. Attendance at a Conservative Christian college, as compared to secular institutions, did not predispose a teacher to spend fewer class periods on evolution.

With regard to features of the educations of the participants, neither the possession of a degree in biological sciences, nor an advanced degree (even in the biological sciences) was related to emphasis on evolution. This was one of the most remarkable findings: a biology major was no more or less likely than a sociology major or English major to emphasize evolutionary theory. What did predict teacher behavior was a positive relationship between emphasis given evolution and the number of college
classes completed by the teacher in the biological sciences, particularly those that explicitly addressed evolutionary theory. This latter variable was most strongly related to emphasis on evolution of all of the demographic variables. However, nearly one-third of Arizona high school biology teachers had never had such a class, nearly half had had no coursework that addressed human evolution, and three-quarters had never had a class that explicitly addressed the evolution/creation debate.

Surely, this points to some educational deficiencies in the preparation of undergraduates in the discipline of biology education. An undergraduate seeking a bachelor’s degree in biology education from any of the Arizona state universities is currently required to take only one introductory level class in ecology and evolutionary biology (UA, ASU, NAU)—Bio 182 at all three universities. I have been a teaching assistant for this course at the University of Arizona for nearly ten years, and can attest that the coverage of evolutionary theory varies dramatically from year to year, and has most often been cursory. None of the course descriptions associated with the remaining course requirements in biological sciences for biology education majors at the three state universities mention anything about evolution, but consist of coursework in plant biology, microbiology, marine biology, etc. A single 100-level survey course in ecology and evolutionary biology is not adequate to prepare a teacher to give evolutionary theory and its central role in biology the emphasis it warrants—nor even to understand this complex topic adequately themselves. Prospective teachers require not only greater depth in this particular subject, but also coursework in the nature and history of science, including the history of interaction of science and religion. If ten-percent of Arizona high
school teachers reject the scientific validity of evolution, and nearly one-third either
claim scientific validity for creationism or are uncertain, then too many do not understand
the nature of science.

Teachers with more experience, and those few that had participated in in-service
training in the teaching of evolution also tended to give evolution more emphasis,
independent of age. Perhaps, over time, teachers educate themselves, and become more
comfortable with a complex topic that most of them characterized as highly controversial
to the general public. A handful of non-respondents sent back their blank questionnaires
with a note indicating that they were first-year teachers, and not ready to "deal with this
topic." This is also an area where intervention could be very effective, in the form of
more in-service workshops on the teaching of evolutionary theory and on the handling of
questions or confrontation on the topic.

Predictors of Emphasis on Evolution: Religious Factors

The variables most strongly and negatively related to emphasis given evolution in
correlations were religious fervor and religious denomination, such that the more
important religion was to a teacher, the less he/she emphasized evolution; members of
Conservative Christian denominations were also less likely to emphasize evolution. This
same result obtained in the regression analyses, which showed that, in terms of single
variables, the negative effects religious fervor and Conservative Christian religious
affiliation on emphasis on evolution were surpassed in magnitude only by coursework in
evolutionary theory. This effect was swamped, and became non-significant when teacher
attitudes towards evolution (to be discussed below) were factored in.
The path analysis showing these religious variables interacting with attitudes and behavior demonstrated that the combined effects of Conservative Christian religious fervor, both directly on emphasis given evolution, and indirectly via its strong influence on attitudes towards evolution make it by far the biggest (and negative) contributor to teacher emphasis on evolution. This is also one aspect of teacher make-up that is unlikely to change over time, and very difficult (and perhaps inappropriate) to influence. It is difficult to imagine the situation in which supporters of evolution education could recommend against the hiring of Conservative Christian biology teachers, nor the situation in which overt attempts to influence the religious beliefs of educators would be acceptable, despite the strong negative impacts those beliefs have on the teaching of the biological sciences.

It might be advisable, however, for teachers-in-training (or high school students, for that matter) to address real (or merely apparent) conflicts between their religious beliefs and evolutionary theory, perhaps in the context of the history of science, or in a course on science teaching methods. Many people never make conscious attempts to integrate their religious beliefs with the findings of science (or are unaware of the official position of their church on this issue) and often assume some sort of dichotomy—i.e., that one can accept either science or religion on the topic of origins, but not both. Studies show that addressing the issue explicitly and showing the range of accommodations possible improve attitudes towards evolution in religious biology teachers (Matthews 2001; Meadows et al. 2000). By a range of accommodations, I refer, for example to 1) metaphysical naturalism, the belief that natural phenomena are adequate to explain all of
reality; 2) deism, which casts a supreme being in the role of original creator of the universe and its natural laws, who then stands back and lets them take their natural course; and 3) directed evolution, in which a hands-on supreme being guides the processes of evolution, giving them purpose and direction. One could certainly find other intermediary positions. The point is that the issue is not a dichotomy, and teachers in training need to understand that, not just for themselves, but for the students they will guide in their classrooms.

Predictors of Emphasis on Evolution: Attitudes

A strong majority (~90%) of the respondents to the survey had positive attitudes towards evolution, indicating that they believed that evolutionary theory is an important unifying concept in biology, that it has a valid scientific foundation, and that it should be taught as part of high school biology classes. However, only three-quarters of them actually spend much time on the topic. Thus, attitude alone does not entirely explain teacher behavior. Time was indicated as a constraint in the write-in portion of the questionnaire, with teachers commenting that there were so many other topics to cover, evolution sometimes got left out. Several teachers wrote in something along the lines of "there are too many other important topics to cover." This seems to indicate that some teachers may view evolution as a discrete unit, like photosynthesis, rather than an integral part of all aspects of biology. Again, this points to shortcomings in the educations of these teachers.

All of the individual attitude items, with the exception of the item asking about the views of the general public towards evolution, had significant correlations with the
amount of emphasis given evolution. A composite evolution attitude score was calculated (employing a principal component analysis of the opinion variables) by summing the responses to the four variables with the highest loadings on Component 2; the same process was also used to create an attitude towards creation score using component loadings for Component 1 (see Appendix C). Correlations and simple regressions between those scores and classroom emphasis showed that those teachers with high evolution attitude scores emphasized evolution more, and creation less; those with high creation scores emphasized creation more and evolution less.

**Predictor Interactions in Emphasis Given Evolution**

A series of regression models was generated in order to evaluate the interactions between the demographic and attitude variables, and to measure the relative magnitudes of their effects on the amount of emphasis given evolution by teachers.

Not surprisingly, opinion swamped—i.e., made non-significant—all other effects on teacher emphasis, except exposure to evolutionary theory in college coursework and teaching experience. The path analysis performed using these regression coefficients illustrates the fact that the biggest contributors to opinion, in turn, were the strong negative influence of the Conservative Christian/fervor interaction factor, and at much smaller magnitude, the positive influence of college coursework in evolutionary theory.

This path analysis highlights what is probably the best way to influence teacher behavior in emphasizing evolution. It is difficult to change peoples’ attitudes, particularly those that have a strong religious foundation. The investment that
Conservative Christians have made an anti-evolutionary stance was documented in the introductory chapters of this thesis.

However, coursework that explicitly addresses evolution, the largest contributor to teacher behavior after attitude, can be influenced by those interested in strengthening evolution education. It seems clear from all of the above analyses, that the best way to improve the teaching of evolution in the public schools is to revise the requirements for teaching degrees in biology to include coursework in the nature and history of science, a full semester devoted to evolutionary theory, and coursework in how to handle confrontation from parents, students, and others.

**Emphasis Given Creation**

More than half of the respondent teachers reported giving some emphasis to creation, but nearly three-quarters said that there was no class period during the semester in which creation as a major theme. Thus, 28% of Arizona high school biology teachers devoted some significant amount of class time to the topic of creation. It is unclear whether these teachers were presenting it as a competing scientific theory, or as a philosophical or social issue, although 60% of those giving moderate-to-strong emphasis to creation reported believing it to be a scientifically valid theory. Thus, while nearly one-third of Arizona high school biology teachers included creation, it seems that only about 8% taught it as a scientific theory (i.e., 60% of the 14% who gave moderate-to-strong emphasis). While this is a relatively small proportion, it is possible that the modifications to teacher education discussed above could also reduce the number of teachers who confuse religious belief with a scientifically supported theory.
Predictors of Emphasis on Creation: Education and Experience

The amount of emphasis a teacher gave to creation in this survey population was unrelated to any aspect of education, teaching experience, or teaching environment, except number of college classes taken in evolutionary biology, with which emphasis given creation was positively related. Teachers who had taken more classes in evolutionary biology reported spending more time on creation, but attitude measures showed that these same teachers rejected creationist beliefs (i.e., had low creationist attitude scores). For those with positive creationist attitude scores, apparently, nothing that he/she learns in college or through the experience of teaching has any impact on his/her behavior in the classroom with regard to emphasizing evolution.

Predictors of Emphasis on Creation: Religious Factors

The only features of teachers or their school environment that had a significant relationship to emphasis given creation were the positive effects of religious fervor and membership in Conservative Christian denominations. Those teachers who reported that religion was important in their lives emphasized creation more, as did those who self-identified as belonging to Conservative Christian denominations. The fact that these relationships hold, independent of education or teaching experience seems to indicate that these variables reflect aspects of personality and inclination that form early in life, and are unassailed by later experience.

Predictors of Emphasis on Creation: Attitudes

In contrast to the case of emphasis given evolution, many of the opinion items did not correlate with emphasis given creation. Items relating to public opinion of
evolutionary theory, the possibility of being religious and still accepting evolutionary
theory, the appropriateness of human evolution for high school students, discomfort with
teaching human evolution, perceptions of adequacy of one's education, avoidance of the
word 'evolution', and preparation for confrontation did not relate to emphasis on
creation. Favor for the inclusion of creation in high school biology courses, and a belief
that creation has a scientifically valid foundation correlated positively with emphasis
given creation, while attitudes about the validity, centrality, and relevance of evolutionary
theory correlated negatively. Favorable attitudes towards creation, not surprisingly, were
also significant in regression models of emphasis on creation ($r^2 = .232$). In other words,
the opinions that related to emphasis given creation in the classroom were more tightly
focused around specific Conservative Christian religious beliefs, embracing creation and
rejecting evolution.

Again, while it may be neither possible nor desirable to attempt to influence
teachers' religious beliefs, coursework that explicitly lays out the scientific evidence in
support of evolution, that is clear about what constitutes scientific evidence, and that
allows teachers to explore the possible accommodations between religion and science,
may go some way to reducing the number of teachers who favor creation, in part due to
negative attitudes towards evolution.

**Evolution/Creation Interactions**

Emphasizing creation did not come as a result of reduced emphasis on evolution
in this survey population, as emphases given the two topics was not related either as an
ordinal correlation \((\gamma = -.003, p = .966)\) or as a regression \((F = 1.468, df = 1, p = .266, r^2 = .004)\). Teachers apparently covered evolution, independent of their coverage of creation.

As discussed above, significant relationships were found between emphasis on creation and negative attitudes towards evolution. That is, those who did not accept the scientific validity of evolutionary theory (in fact, who believed that there is scientific evidence that disproves evolution), who rejected the centrality and relevance of evolution to the classes they taught, who reporting feeling conflicted about teaching it, and who rejected evolution for humans in particular tended to emphasize creation to a greater degree.

Clearly, there is a negative correlation between attitudes towards evolution and emphasis given creation, but the relationship is actually the weakest of the effects of attitude (as measured by the evolution attitude score) on behavior; the \(r^2\) for this effect was only .007. This finding may support the conclusion that a wide range of attitudes towards evolution produces similar effects on the amount of emphasis given creation, or conversely, that similar attitudes towards evolution produce varying degrees of emphasis on creation. In either case, something other than attitude towards evolution is making a significant contribution to the amount of emphasis a teacher gives creation.

By contrast, the relationship between the creation attitude score and teacher emphasis on creation was much higher \((r^2 = .200)\), which is not surprising. The lower explanatory power of opinion for emphasis on creation, in comparison with opinion and emphasis on evolution \((r^2 = .268)\), may be due to the current, and widely known legal strictures against advocating religious viewpoints in public schools. Approximately one-
third of the participants believed that creation should be taught as part of high school biology classes, and a quarter believed creation to have a valid scientific foundation. However, a much smaller percentage (6%) actually spent significant time on the topic. Presumably, they are being restrained from teaching what they believe to be important by some exterior force. Most teachers are no doubt aware that the Supreme Court has consistently rejected the teaching of creation as a violation of the separation of church and state.

Additionally, the two attitude scores are more closely related to one another than either is to teacher emphasis on creation \((r^2 = .242)\). Knowing a teacher’s attitude about one topic allows one to more accurately predict his/her attitude towards the other topic than either attitude would allow one to predict teacher emphasis given creation in the classroom. This again reinforces the notion that negative attitudes toward evolution and positive attitudes toward creation (and vice versa) are closely interwoven. As discussed above, while changing attitudes towards creation may not be an appropriate goal, improving attitudes toward evolution may lower the effect of attitudes towards creation on classroom behavior.

It also underscores the greater disconnect between teacher attitude and teacher behavior on the topic of creation than was the case for evolution. Teachers are apparently being restrained from acting on their beliefs regarding creation, perhaps because they are aware of the controversy over teaching religion in the schools. Unfortunately, the survey did not measure outside influences on teaching creation, so I can only speculate.
Conclusions

Only one-third of Arizona high school biology teachers in the year 2000 strongly emphasized evolutionary theory in their classrooms, while fifteen percent gave creation a significant amount of emphasis.

If we care about quality biology education, our goal should be to increase the amount of emphasis evolution gets in high school classes. Whether a parallel goal is to reduce the emphasis given creation is another matter. Creationism should not be taught as an alternative scientific theory; the hypotheses that derive from it have been falsified. A case can be made, however, that in an effort to prevent the alienation of religious students, it may be necessary to address the differences in the bases knowledge claims between science and other ways of generating information about the world. It is also important that students realize that this is not a dichotomous issue: accept science and you must reject religion, or vice versa.

In this study, the same four independent variables (teacher experience, coursework in evolutionary biology, religious fervor, and Conservative Christian church membership) were the sole significant predictors of either the amount of emphasis a teacher gave evolutionary theory or the amount of emphasis given creation.

As educators of future educators, there is probably very little we can do about the religious variables that affect the teaching of evolution and creation; the ethics of attempts to directly influence peoples' religious beliefs, even in the service of improved science education, is something we must examine carefully.
We can also have little effect on the number of years of teaching experience a teacher has, unless, we can somehow, as voters, influence teacher pay in order to retain good teachers longer.

We can affect prospective teachers' exposure to evolutionary biology as part of teacher training, by revising curricula to include more mandatory coursework in evolutionary biology, and in how to teach it. The biology teacher training programs at all three Arizona state universities currently require a single introductory-level 3-unit course in ecology and evolutionary biology. Having been a teaching assistant and lab instructor in this course for nearly ten years, I can attest that the coverage of evolution is highly variable, and often quite cursory.

Teachers need a stronger foundation in evolutionary biology and the nature of science than they currently receive. They also need training in how to teach evolution and how to address the concerns of parents and students when science seems to conflict with religion. Teacher training curricula must be revised to increase the foundations of future teachers in the central explanatory framework of their chosen discipline, and to explicitly address the differences between science and other "ways of knowing." If undergraduates have not yet grappled with the possible conflicts between science and religion on the topic of origins, both in their own minds and the minds of their future students, then they must be given the opportunity to do so. Simply drawing a line between science and religion is not adequate. There are too many teachers and students who will be psychologically drawn to a world guided by a loving, purposeful creator, rather than one guided by seemingly cold, blind evolutionary forces unconcerned with
human ego. It must be clear to all that there is a range of possible accommodations between religion and science on this issue.

By increasing class hours in evolutionary biology required for a teaching degree in the biological sciences, we can increase the emphasis that teachers give evolution by improving their understanding of the topic, and increasing their confidence in teaching it. Such coursework is also associated with negative attitudes towards creationism. By introducing coursework on the history of science and conflicts with religion, hopefully we can reduce the level of negative attitudes toward evolution (and possibly, positive attitudes towards creation as a scientific theory), and further reinforce the emphasis given evolution by biology teachers.

My last note is a caveat, with regard to additional coursework. Teachers with more exposure to evolutionary theory in college emphasized it more in their classrooms. But is the relationship between coursework and emphasis necessarily causative, or merely correlative? That is, can we assume that greater exposure to evolution results in better attitudes and greater emphasis on evolution in the classroom, or did teachers who took more evolutionary biology do so because they have no religious or philosophical conflicts with evolutionary theory to begin with? Are future teachers with such conflicts self-selecting out of such classes because they can? If so, increasing the course requirements in evolutionary biology might cause people with religious/philosophical conflicts with evolution to choose other careers. Would this be a good thing? We might ask ourselves if reducing the diversity of viewpoints in the classroom, in the interests of improving the
quality of biology education is a worthy goal. There may be perils associated with either choice.
Appendix A: Surveys of Teachers and Students Regarding Evolution/Creation

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Subjects (sample)</th>
<th>Return Rate</th>
<th>sampling method</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burnett, R.W.</td>
<td>1941</td>
<td>National, science teachers (members of National Education Assoc.)</td>
<td>27% n=2309</td>
<td>census</td>
<td>no quantitative data given</td>
</tr>
<tr>
<td>Riddle, O.</td>
<td>1942</td>
<td>National, high school biology teachers (members of Union of Biological Societies)</td>
<td>n/a n=3075</td>
<td>census</td>
<td>sample drawn from professional association membership lists</td>
</tr>
<tr>
<td>Laba, E.R. and E.W. Gross</td>
<td>1950</td>
<td>Essex County NJ biology teachers</td>
<td>45% n=29</td>
<td>census</td>
<td>single NJ county; very small sample size</td>
</tr>
<tr>
<td>Martin, W.E.</td>
<td>1951</td>
<td>National sample of 1000 high schools</td>
<td>60% n=115</td>
<td>random</td>
<td>sampled schools, not teachers</td>
</tr>
<tr>
<td>Troost, C.E.</td>
<td>1966</td>
<td>Indiana high school biology teachers, stratified by community size</td>
<td>66% n=363</td>
<td>stratified</td>
<td>sample taken from professional association membership list (NSTA)</td>
</tr>
<tr>
<td>Christenson, H.T. and K.L. Cannon</td>
<td>1978</td>
<td>Longitudinal study of university students at BYU, Provo UT</td>
<td>n/a</td>
<td>census</td>
<td></td>
</tr>
<tr>
<td>Bergman, J.</td>
<td>1979</td>
<td>Seniors and grad students in teacher-training at Bowling Green State University in Ohio</td>
<td>n/a n=516</td>
<td>census</td>
<td></td>
</tr>
<tr>
<td>Nelkin, D.</td>
<td>1982</td>
<td>Science teachers attending a National Science Teachers Association national meeting in 1972</td>
<td>12% n=147</td>
<td>census</td>
<td>very low return rate</td>
</tr>
<tr>
<td>Author</td>
<td>Year</td>
<td>Subjects (sample)</td>
<td>Return Rate</td>
<td>sampling method</td>
<td>Limitations</td>
</tr>
<tr>
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<td>-----------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Buckner, E.M.</td>
<td>1983</td>
<td>high school science teachers in an Atlanta GA county where approval of equal time was perceived to be high</td>
<td>67% n=65</td>
<td>census; judgmental sample</td>
<td>small, non-representative sample</td>
</tr>
<tr>
<td>Eglin, P.G.</td>
<td>1983</td>
<td>high school biology teachers from 4 communities in the Atlanta area, stratified by school size</td>
<td>32% n=128</td>
<td>stratified random</td>
<td>low response rate</td>
</tr>
<tr>
<td>Ellis, E.W.</td>
<td>1983</td>
<td>all high school biology teachers in KY, plus a sample from IN and TN</td>
<td>44-53% n&gt;500</td>
<td>census + random</td>
<td></td>
</tr>
<tr>
<td>Fuerst, P.A.</td>
<td>1984</td>
<td>Undergraduate students in 10 different science classes at Ohio State University</td>
<td>n/a n=2387</td>
<td>census</td>
<td></td>
</tr>
<tr>
<td>Nickels, M. and B. Drummond</td>
<td>1985</td>
<td>Public school science teachers attending a state conference (IL)</td>
<td>n/a</td>
<td>census</td>
<td>professional association conference attendees</td>
</tr>
<tr>
<td>Affannato, F.E.</td>
<td>1986</td>
<td>National sample of biology teachers (NSTA)</td>
<td>47% n=467</td>
<td>random</td>
<td>sample drawn from professional association membership lists</td>
</tr>
<tr>
<td>Zimmerman, M.</td>
<td>1986</td>
<td>undergraduate students at Oberlin College, Ohio</td>
<td>n/a n=362</td>
<td>census</td>
<td></td>
</tr>
<tr>
<td>Roelfs, F.C.</td>
<td>1987</td>
<td>1 junior or senior high school biology teacher from each district in AK and MO</td>
<td>47% n=353</td>
<td>census of districts</td>
<td>only 1 teacher per district</td>
</tr>
<tr>
<td>Zimmerman, M.</td>
<td>1987</td>
<td>Ohio high school biology teachers; sampled departments</td>
<td>29% n=404</td>
<td>random</td>
<td>low response rate</td>
</tr>
<tr>
<td>Author</td>
<td>Year</td>
<td>Subjects (sample)</td>
<td>Return Rate</td>
<td>sampling method</td>
<td>Limitations</td>
</tr>
<tr>
<td>-------------------------------</td>
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<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Van Koevering, T.E., and R.B. Stiehl</td>
<td>1989</td>
<td>Sample of WI high school biology teachers, stratified by community size; with approval of 80% of school districts</td>
<td>90%</td>
<td>stratified random</td>
<td>district approval was necessary for teacher participation</td>
</tr>
<tr>
<td>Tatina, R.</td>
<td>1989</td>
<td>SD public and private high school biology teachers</td>
<td>47% n=99</td>
<td>census</td>
<td></td>
</tr>
<tr>
<td>Shankar, G.</td>
<td>1989</td>
<td>National sample of public school biology teachers belonging to National Science Teachers Association</td>
<td>49% n=307</td>
<td>random</td>
<td>sample drawn from professional association membership lists</td>
</tr>
<tr>
<td>Fisher, R.T.</td>
<td>1989</td>
<td>Sample of science teachers belonging to National Science Teachers Association</td>
<td>49% n=191</td>
<td>random</td>
<td>sample drawn from professional association membership lists</td>
</tr>
<tr>
<td>Miller, E.</td>
<td>1990</td>
<td>Census of AL high schools</td>
<td>63% n=236</td>
<td>census of schools</td>
<td>only one teacher per school was surveyed (self-selection?)</td>
</tr>
<tr>
<td>Eve, R.A. and D. Dunn</td>
<td>1990</td>
<td>National sample of high school biology teachers belonging to National Science Teachers Association</td>
<td>49% n=190</td>
<td>random</td>
<td>sample drawn from professional membership lists (NSTA)</td>
</tr>
<tr>
<td>Scharmann, L.C.</td>
<td>1993</td>
<td>Senior undergraduate biology education majors at KSU</td>
<td>n/a n=25</td>
<td>census</td>
<td>small sample size</td>
</tr>
<tr>
<td>Author</td>
<td>Year</td>
<td>Subjects (sample)</td>
<td>Return Rate</td>
<td>sampling method</td>
<td>Limitations</td>
</tr>
<tr>
<td>-----------------------------</td>
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</tr>
<tr>
<td>Huang, H.H.</td>
<td>1995</td>
<td>All Iowa high school biology teachers</td>
<td>55%</td>
<td>census</td>
<td>n=343</td>
</tr>
<tr>
<td>Sinclair, A., M.P.</td>
<td>1997</td>
<td>Undergraduate zoology students at Southeastern Louisiana University (58% were science majors)</td>
<td>n/a</td>
<td>census</td>
<td>n=218</td>
</tr>
<tr>
<td>Osih, B.A.</td>
<td>1997</td>
<td>Sample of PA school districts, principal approval required; 42% of schools (n=21) agreed to participate; science and English teachers</td>
<td>66%</td>
<td>random sample of districts</td>
<td>majority of school districts refused to participate; small sample size</td>
</tr>
<tr>
<td>Aguillard, D.</td>
<td>1998</td>
<td>Census of LA school districts; 77% agreed to participate (n=51); high school biology teachers</td>
<td>64%</td>
<td>census</td>
<td>n=387</td>
</tr>
<tr>
<td>Weld, J. and J. McNew</td>
<td>1999</td>
<td>OK high school biology teachers</td>
<td>49%</td>
<td>census</td>
<td>n=224</td>
</tr>
<tr>
<td>Rutledge, M. and M. Warden</td>
<td>2000</td>
<td>IN high school biology teachers</td>
<td>53%</td>
<td>census</td>
<td>n=552</td>
</tr>
</tbody>
</table>


Appendix B:
ARIZONA BIOLOGY TEACHERS SURVEY

INSTRUCTIONS: Please circle the letter that corresponds to your answer. Remember that your answers will be kept strictly confidential, so please be honest! Please return your completed survey before March 15, 2000 in the attached postage-paid, pre-addressed return envelope. Thank you! [n=419; bracketed nos. = nos. of responses]

1. Please characterize the amount of emphasis you give the topic of evolution in the biology classes that you teach.
   a. No emphasis. [15]
   b. Little emphasis. [52]
   c. Moderate emphasis. [187]
   d. Strong emphasis. [134]

2. Please characterize the amount of emphasis you give to religious explanations for the origins/diversity of life in the biology classes you teach.
   a. No emphasis. [192]
   b. Little emphasis. [17]
   c. Moderate emphasis. [49]
   d. Strong emphasis. [9]

3. In how many class periods per semester is evolution a major theme?
   a. None [46]
   b. 1-3 [102]
   c. 3-5 [82]
   d. 5-7 [54]
   e. More than 7 [134]

4. In how many class periods per semester is creation a major theme?
   a. None [299]
   b. 1-3 [92]
   c. 3-5 [13]
   d. 5-7 [5]
   e. More than 7 [8]

5. How many class periods per semester do you devote explicitly to human evolution?
   a. None [151]
   b. 1-3 [170]
   c. 3-5 [48]
   d. 5-7 [20]
   e. More than 7 [27]

6. Please characterize the degree to which you are influenced by each of the following groups in your decision whether and how to teach evolution:
   a. The National Science Education Standards
      a. Strong encouragement to teach evolution [69]
      b. Encouragement to teach evolution [164]
      c. No influence [177]
      d. Discouragement from teaching evolution [9]
      e. Strong discouragement from teaching evolution [0]
   b. The Arizona State Board of Education Curriculum Standards
      a. Strong encouragement to teach evolution [49]
      b. Encouragement to teach evolution [187]
      c. No influence [168]
      d. Discouragement from teaching evolution [8]
      e. Strong discouragement from teaching evolution [0]
   c. Your local School Board
      a. Strong encouragement to teach evolution [19]
      b. Encouragement to teach evolution [72]
      c. No influence [298]
      d. Discouragement from teaching evolution [18]
      e. Strong discouragement from teaching evolution [8]
   d. Your district science curriculum administrator (leave blank if you don't have one) [n=254]
      a. Strong encouragement to teach evolution [24]
      b. Encouragement to teach evolution [93]
      c. No influence [130]
      d. Discouragement from teaching evolution [6]
      e. Strong discouragement from teaching evolution [1]
   e. Your department head (leave blank if you don't have one) [n=357]
      a. Strong encouragement to teach evolution [60]
      b. Encouragement to teach evolution [99]
      c. No influence [193]
      d. Discouragement from teaching evolution [4]
      e. Strong discouragement from teaching evolution [1]
   f. Other teachers
      a. Strong encouragement to teach evolution [51]
      b. Encouragement to teach evolution [115]
      c. No influence [229]
      d. Discouragement from teaching evolution [17]
      e. Strong discouragement from teaching evolution [2]
   g. Parents (of your students)
      a. Strong encouragement to teach evolution [3]
      b. Encouragement to teach evolution [24]
      c. No influence [320]
      d. Discouragement from teaching evolution [54]
      e. Strong discouragement from teaching evolution [10]
13. Students
   a. Strong encouragement to teach evolution [10]
   b. Encouragement to teach evolution [75]
   c. No influence [252]
   d. Discouragement from teaching evolution [63]
   e. Strong discouragement from teaching evolution [5]

14. If there are any other influences on your decisions about teaching evolution, please specify:
   a. Strong encouragement to teach evolution
   b. Encouragement to teach evolution
   c. No influence
   d. Discouragement from teaching evolution
   e. Strong discouragement from teaching evolution

15. Please rank the four (1-4) most important influences on your decision on whether and how to teach general evolutionary theory:
   (1 is most important, 2 is next most important, and so on) [no. who ranked this in top 4]
   [206] National Science Education Standards
   [220] Arizona State Curriculum Standards
   [89] your local school board
   [52] your department head
   [165] the textbook provided to you
   [91] other teachers
   [56] parents
   [98] students
   [64] your religious beliefs
   [79] your desire to avoid controversy
   [241] your level of knowledge of evolutionary principles
   ____ other (please specify)

17. Do you have any input in the choice of textbooks for the classes you teach?
   a. Yes [341]
   b. No [89]

18. To what degree does the manner in which evolution is presented in the textbooks for your classes determine how you present that subject in class?
   a. Completely (100%) [23]
   b. To quite an extent (~66%) [125]
   c. Somewhat (~33%) [182]
   d. Not at all (0%) [80]

19. To what degree does textbook content determine whether/how you present human evolution?
   a. Completely (100%) [23]
   b. To quite an extent (~66%) [95]
   c. Somewhat (~33%) [150]
   d. Not at all (0%) [139]

20. To what extent is human evolution covered in the texts you use?
   a. Extensive coverage [49]
   b. Moderate coverage [205]
   c. Little coverage [137]
   d. No coverage [15]

21. Do you have time to keep up with publications on advances in biology?
   a. Yes [216]
   b. No [186]

22. Please list any books (other than high school texts) or magazines/journals you have read in the last three years that deal explicitly with evolution and/or creationism.

The following questions address your opinions, as opposed to what you may actually do in your classes. Please characterize your degree of agreement/disagreement with the following statements:

23. Evolution should be taught as part of high school biology classes.
   a. Disagree strongly [7]
   b. Disagree [13]
   c. Agree [125]
   d. Agree strongly [261]
   e. Don't know/no opinion [9]

24. Religious explanations for the origin and diversity of life on Earth should be taught in high school biology classes.
   a. Disagree strongly [171]
   b. Disagree [102]
   c. Agree [100]
   d. Agree strongly [31]
   e. Don't know/no opinion [10]

25. The teaching of evolution is a highly controversial subject for the American public.
   a. Disagree strongly [8]
   b. Disagree [85]
   c. Agree [223]
   d. Agree strongly [90]
   e. Don't know/no opinion [8]

26. The theory of evolution has a valid scientific foundation.
   a. Disagree strongly [13]
   b. Disagree [21]
   c. Agree [120]
   d. Agree strongly [253]
   e. Don't know/no opinion [7]

27. Creationism has a valid scientific foundation.
   a. Disagree strongly [181]
   b. Disagree [109]
   c. Agree [66]
   d. Agree strongly [24]
   e. Don't know/no opinion [31]
<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
</table>
| 28. It is possible for a person to have strong religious beliefs and at the same time embrace scientific explanations of evolution. | a. Disagree strongly [7]  
   b. Disagree [13]  
   c. Agree [148]  
   d. Agree strongly [233]  
   e. Don't know/no opinion [12] |
| 29. I feel conflicted about the teaching of evolution, due to my personal religious beliefs. | a. Disagree strongly [216]  
   b. Disagree [129]  
   c. Agree [40]  
   d. Agree strongly [20]  
   e. Don't know/no opinion [8] |
| 30. I would like to teach creationism as well as evolution in my classes. | a. Disagree strongly [196]  
   b. Disagree [98]  
   c. Agree [71]  
   d. Agree strongly [31]  
   e. Don't know/no opinion [18] |
| 31. The topic of evolution is not really relevant to the courses I teach. | a. Disagree strongly [217]  
   b. Disagree [144]  
   c. Agree [28]  
   d. Agree strongly [10]  
   e. Don't know/no opinion [13] |
| 32. The study of human evolution is not appropriate for high school students. | a. Disagree strongly [196]  
   b. Disagree [153]  
   c. Agree [39]  
   d. Agree strongly [9]  
   e. Don't know/no opinion [18] |
| 33. There is scientific evidence that disproves evolutionary theory. | a. Disagree strongly [156]  
   b. Disagree [131]  
   c. Agree [45]  
   d. Agree strongly [23]  
   e. Don't know/no opinion [56] |
| 34. Evolution is an important unifying concept in biology. | a. Disagree strongly [15]  
   b. Disagree [27]  
   c. Agree [139]  
   d. Agree strongly [225]  
   e. Don't know/no opinion [9] |
| 35. The fossil record is much too fragmentary to be interpreted as supporting the theory of evolution. | a. Disagree strongly [150]  
   b. Disagree [170]  
   c. Agree [46]  
   d. Agree strongly [19]  
   e. Don't know/no opinion [28] |
| 36. Humans evolved from an ape-like ancestor in Africa, beginning millions of years ago. | a. Disagree strongly [53]  
   b. Disagree [36]  
   c. Agree [131]  
   d. Agree strongly [133]  
   e. Don't know/no opinion [57] |
| 37. Humans have been subject to the same evolutionary forces as other animals and plants. | a. Disagree strongly [14]  
   b. Disagree [28]  
   c. Agree [156]  
   d. Agree strongly [201]  
   e. Don't know/no opinion [14] |
| 38. I feel less comfortable teaching the evolution of humans than the evolution of plants and animals. | a. Disagree strongly [100]  
   b. Disagree [119]  
   c. Agree [140]  
   d. Agree strongly [37]  
   e. Don't know/no opinion [17] |
| 39. I feel that my educational background in evolutionary theory has adequately prepared me to teach it in my classroom. | a. Disagree strongly [14]  
   b. Disagree [54]  
   c. Agree [177]  
   d. Agree strongly [153]  
   e. Don't know/no opinion [5] |
| 40. I tend to avoid use of the term "evolution" in my classes. | a. Disagree strongly [162]  
   b. Disagree [193]  
   c. Agree [48]  
   d. Agree strongly [7]  
   e. Don't know/no opinion [5] |
| 41. I feel adequately prepared to deal with confrontation from students or parents on the topic of evolutionary theory. | a. Disagree strongly [16]  
   b. Disagree [47]  
   c. Agree [227]  
   d. Agree strongly [117]  
   e. Don't know/no opinion [5] |
| 42. Opportunities to gain skills in teaching evolution are available to me. | a. Disagree strongly [34]  
   b. Disagree [122]  
   c. Agree [160]  
   d. Agree strongly [34]  
   e. Don't know/no opinion [62] |
| 43. I would like to increase my knowledge of evolutionary theory and its role in the teaching of biology. | a. Disagree strongly [11]  
   b. Disagree [53]  
   c. Agree [231]  
   d. Agree strongly [91]  
   e. Don't know/no opinion [29] |
44. I would like to increase my knowledge of human evolution.
   a. Disagree strongly [16]
   b. Disagree [44]
   c. Agree [22]
   d. Agree strongly [103]
   e. Don't know/no opinion [24]

45. To increase my knowledge of human evolution, I would be willing to (circle all that apply):
   a. Take an university course [197]
   b. Attend an in-service workshop [301]
   c. Do reading on my own [308]
   d. Consult with university curriculum advisors [132]
   e. Other (please specify) [19]

The following questions are demographic in nature, intended to gather information on the backgrounds of Arizona high school biology teachers as a group.

46. Please characterize your educational level:
   a. Some college [0]
   b. Bachelor's Degree [42]
   c. Some post-graduate courses [125]
   d. Master's Degree [100]
   e. Some post-Master's coursework [130]
   f. Other (please specify) [19]

47. In what field is your Bachelor's Degree?
   a. Education [73]
   b. Biological Sciences [251]
   c. Other (please specify) [92]

48. In what field was your undergraduate minor? (Please specify)

49. In what year did you receive your Bachelor's Degree?

50. From what college/university did you receive your Bachelor's Degree?

51. In what field is your Master's Degree, if you have one?
   a. Education [145]
   b. Biological Sciences [62]
   c. Other (please specify) [37]

52. For how many years have you taught biology? [x=10.5]

53. Which biology classes do you normally teach? (Please specify)

54. How many college courses have you completed in the biological sciences?
   a. None [2]
   b. 1-3 [8]
   c. 4-6 [41]
   d. 7 or more [364]

55. How many college courses have you completed that explicitly addressed the subject of evolution?
   a. None [115]
   b. 1-3 [212]
   c. 4-6 [44]
   d. 7 or more [43]

56. How many college courses have you taken that explicitly addressed human evolution?
   a. None [202]
   b. 1-3 [187]
   c. 4 or more [26]

57. How many college courses have you taken that explicitly addressed the evolution/creation debate?
   a. None [298]
   b. 1-3 [108]
   c. 4 or more [9]

58. How much instruction in the teaching of evolution have you received as a practicing teacher (e.g., in graduate courses, workshops, etc.)?
   a. None [269]
   b. Some [115]
   c. A moderate amount [20]
   d. Quite a bit [10]

59. What is your gender?
   a. Male [212]
   b. Female [203]

60. What is your age?
   a. Under 30 [67]
   b. 31-40 [140]
   c. 41-50 [114]
   d. 51-60 [87]
   e. Over 60 [6]

61. What is your religious affiliation?
   a. Atheist [14]
   b. Agnostic [49]
   c. Catholic [111]
   d. Conservative Christian [43]
   e. Other Protestant [119]
   f. Jewish [7]
   g. Muslim [1]
   h. Buddhist [3]
   i. Other (please specify) [60]

62. How important is religion in your life?
   a. Unimportant [80]
   b. Somewhat important [161]
   c. Very important [171]

63. How important are politics in your life?
   a. Unimportant [67]
   b. Somewhat important [262]
   c. Very important [86]

64. Which of the following best describes your political philosophy?
   a. Conservative [103]
   b. Moderate [152]
   c. Liberal [115]
   d. Radical [10]
   e. Apolitical (non-political) [30]

65. Are you willing to be interviewed?
   a. Yes [263]
   b. No [144]
If there are any other comments you'd like to make regarding the teaching of evolution in general, and/or human evolution, please feel free to do so on the reverse side.

Please indicate on the enclosed card if you would like a copy of the research results and/or the curriculum module; include your name and mailing address.

Thank you very much for your time and your input in filling out this questionnaire!
Appendix C:

Principal Components Analysis of Opinion Statements
(Rotated Component Matrix)

<table>
<thead>
<tr>
<th>Question # and Statement (see questionnaire for full text)</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
<th>Component 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q23: evolution should be taught</td>
<td>-.124</td>
<td>.707</td>
<td>-2.74</td>
<td>.173</td>
</tr>
<tr>
<td>Q24: creation should be taught</td>
<td>.855</td>
<td>-.117</td>
<td>.092</td>
<td>-.036</td>
</tr>
<tr>
<td>Q25: evolution is controversial to public</td>
<td>.179</td>
<td>.247</td>
<td>.336</td>
<td>-.068</td>
</tr>
<tr>
<td>Q26: evolution has valid scientific foundation</td>
<td>-.303</td>
<td>.736</td>
<td>-.200</td>
<td>.048</td>
</tr>
<tr>
<td>Q27: creation has valid scientific foundation</td>
<td>.699</td>
<td>-.160</td>
<td>.281</td>
<td>-.136</td>
</tr>
<tr>
<td>Q28: it is possible to be religious and accept evol.</td>
<td>.030</td>
<td>.530</td>
<td>-.127</td>
<td>.036</td>
</tr>
<tr>
<td>Q29: I feel conflicted about teaching evolution</td>
<td>.500</td>
<td>-.282</td>
<td>.264</td>
<td>-.232</td>
</tr>
<tr>
<td>Q30: I would like to teach creation</td>
<td>.848</td>
<td>-.220</td>
<td>.072</td>
<td>-.043</td>
</tr>
<tr>
<td>Q31: evolution is not relevant to courses I teach</td>
<td>.352</td>
<td>-.360</td>
<td>.490</td>
<td>-.082</td>
</tr>
<tr>
<td>Q32: human evol. not appropriate in high school</td>
<td>.161</td>
<td>-.265</td>
<td>.730</td>
<td>-.097</td>
</tr>
<tr>
<td>Q33: there is scientific evidence disproving evol.</td>
<td>.527</td>
<td>-.244</td>
<td>.390</td>
<td>-.104</td>
</tr>
<tr>
<td>Q34: evol. is an important, unifying concept in biol.</td>
<td>-.304</td>
<td>.689</td>
<td>-.095</td>
<td>.216</td>
</tr>
<tr>
<td>Q35: fossil evid. too fragmentary to support evol.</td>
<td>.553</td>
<td>-.294</td>
<td>.438</td>
<td>-.194</td>
</tr>
<tr>
<td>Q36: humans evolved from apelike ancestor mya</td>
<td>-.278</td>
<td>.656</td>
<td>.048</td>
<td>.022</td>
</tr>
<tr>
<td>Q37: humans subj. to same evol. forces as others</td>
<td>-.368</td>
<td>.639</td>
<td>-.029</td>
<td>.198</td>
</tr>
<tr>
<td>Q38: I feel less comfortable teaching human evol.</td>
<td>.088</td>
<td>-.043</td>
<td>.674</td>
<td>-.177</td>
</tr>
<tr>
<td>Q39: my education has adequately prepared me</td>
<td>-.177</td>
<td>.212</td>
<td>-.180</td>
<td>.818</td>
</tr>
<tr>
<td>Q40: I avoid using the word ‘evolution’</td>
<td>.139</td>
<td>-.151</td>
<td>.692</td>
<td>-.206</td>
</tr>
<tr>
<td>Q41: I am prepared to deal with confrontation</td>
<td>-.089</td>
<td>.107</td>
<td>-.218</td>
<td>.863</td>
</tr>
</tbody>
</table>

Rotation Method: Varimax with Kaiser Normalization (rotation converged in 7 iterations)

The components are construed to represent 1) favor towards creationism, 2) favor towards evolutionary theory, 3) discomfort with evolutionary theory, especially human, and 4) feelings of inadequacy regarding teaching or defending evolution.

Total Variance Explained

<table>
<thead>
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<th>Component</th>
<th>Initial Eigenvalues</th>
<th>% of variance</th>
<th>Cumulative %</th>
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<tr>
<td>Total</td>
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<td>36.484</td>
<td>36.484</td>
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<td>2</td>
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<td>8.564</td>
<td>45.048</td>
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<tr>
<td>3</td>
<td>.1425</td>
<td>7.502</td>
<td>52.551</td>
</tr>
<tr>
<td>4</td>
<td>.1030</td>
<td>5.422</td>
<td>57.972</td>
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</table>

Extraction Method: Principal Components Analysis
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