

Science and Mathematics Education Centre

**The Condition and Effects of Evolutionary Education in the
Parochial School**

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Abstract

The purpose of this research was to determine the condition of evolution education in American parochial schools and the effect of evolution education on students' attitudes toward science. Data were gathered using Fraser's Test of Science Related Attitudes (TOSRA) and Bilica's Teaching Evolutionary Topics Survey (TETS). The research participants consisted of 60.3% of biology teachers currently teaching in Lutheran high schools in the United States, and 479 Lutheran high school biology students grades 9-12 in California, Nevada, and Arizona. In the first attitudinal study done specifically on parochial students, statistical analysis confirmed the reliability and validity of the TOSRA instrument for parochial school students. In a quasi-experimental design, analysis revealed that student science attitudes do change as a result of participating in a unit on evolution in the first year biology classes of secondary parochial schools. The emphasis placed by teachers on particular evolutionary topics was also analysed. It was found that all Lutheran high school biology teachers present evolution to some extent although not all topics are emphasized equally. The results also demonstrate that parochial school teachers have nearly the same emphasis placed on evolution as do public school teachers.

Dedication

To

my wife and parents

in recognition of their unfailing love and support.

In thankfulness to God

for His grace, mercy, and faithfulness.

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Show me your ways, O Lord, teach me your paths; guide me in your truth and teach me, for you are God my Saviour, and my hope is in you all day long. Psalm 25:4-5

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CHAPTER 1

Introduction

1.1 Background to the Study

Evolution has long been a topic of controversy in American public science education. At the beginnings of public science education the creation story, as evidenced in Genesis 1:1, was taught nearly exclusively as the beginning to life on the planet. As time progressed, teachers began to explore evolution as the true scientific theory which should be taught. The controversy came to a head in the case of *Scopes v. Board of Education* where Scopes was found to be teaching evolution as an alternative theory (Moore, 2000a). Moving toward today, the creation event has been omitted in science education and evolution is taught as the only legitimate naturalistic explanation for the present state of life on earth.

Private school science education is not subject to state and national laws on the teaching of evolution. There is much latitude given in what must be taught. It is the purpose of this research to better understand the approach taken in the Lutheran high school biology class environment in the teaching of evolution if there is any at all.

This research is of particular interest for three reasons. First, as Cummins, Demastes, and Hafner (1994) show, evolution education is not well researched. Excellent science educators must examine their own pedagogy and the findings of others to become better teachers. Since studies of this type have not been done in parochial school settings before, this will open a gateway for research in an underdeveloped field. Second, as a professor of science education at a religious based institution it is appropriate to research one of the most controversial and talked about subjects in science education. This research will provide empirical evidence about the amount of emphasis placed on evolution in parochial schools and it's effect on student science attitudes. Finally, these results will further refine my understanding of the interaction between science and religion and how they are perceived by teachers and students in the high school biology classroom.

1.2 Rationale for the Study

Evolution as theory is considered to have its official beginnings in the writings of Charles Darwin in his books “The Origin of Species” in 1859 and “The Descent of Man” in 1871. These books put forward the ideas that there are definite relationships amongst biological organisms. These organisms can be classified into taxonomic categories as set out by Carrolus Linnaeus in the 1700’s. Since the organisms seemed to be closely related, Darwin made the connection that there must be relationships between the living organisms and those seen in the fossil record. Since the fossils were organisms which lived before the present time, those fossilized animals and plants must be the ancestors of the current host of organisms on the earth today. As relationship lines are drawn Darwin concluded that by natural selection some animals would be better able to survive and therefore pass on their genes. Organisms which were better able to survive to reproduce would then be considered the “fittest” and pass on their genes. If a mutation were to change the genes of a particular organism to the benefit of that organism, it would be considered an evolutionary step. Over time, the build up of these “steps” would cause large changes in animals, which would produce new species.

Darwin was not unique in his ideas about natural selection. Darwin’s grandfather Erasmus Darwin, a leading intellectual of the 1700’s, proposed evolutionary theory in his book, “The Laws of Organic Life” in 1794. A contemporary of Erasmus Darwin was Jean Baptiste de Lamarck who put forward the ideas of the Theory of Inheritance Acquired Characteristics in his book “Philosophie zoologique” in 1809. This theory said that an organism would gain characteristics in its lifetime and pass those characteristics onto its offspring. This flawed theory has been replaced by Charles Darwin’s theory, but is still taught in schools for its scientific strategy. A contemporary of Darwin, Alfred Wallace, who is little known to the general population had similar views about evolution. Wallace had been in written contact with Darwin and sent to Darwin his paper “On the Tendency of Varieties to Depart Indefinitely From the Original Type.” This paper had ideas about natural selection which agreed with Darwin’s work.

Much of the controversy that surrounds evolution is in its definition. Evolution according to Webster’s college dictionary means “any process of formation or

growth; development” (*Webster's college dictionary*, 1991). For some people the idea of evolution is that organisms over time changed from single celled organisms to humans. This idea has been given the term macroevolution (Johnson, 1993). It is defined as a large change in organisms to create new species. This is counter to the idea of microevolution where organisms adapt in colour or physical feature change while not creating a new species. An example would be the great diversity of dog breeds in the world. For this paper, evolution will refer to macroevolution when not specified.

This study is unique in that the research studies that have been found, strictly deal with the effects that evolution education has on student attitudes and the teaching of evolution in public schools classrooms (Ayala, 2000; Bilica, 2001; Bilica & Skoog, 2002; Ellis, 1986; Osif, 1997; Shankar & Skoog, 1993; Skoog & Bilica, 2002; Tatina, 1989; Van Koevering & Stiehl, 1989). Most papers look at governmental reforms for public schools ("Colorado a victory for science," 1999; Johnson, 1993; "Kansas evolution battle spreads to Kentucky, New Mexico schools," 1999; "Oklahoma attorney general issues ruling against evolution disclaimer," 2000; Russo, 2001; Thomas, 2000; "West Virginia school board supports evolution," 2000), national science groups statements reacting to those reforms ("AAAS statement on the Kansas state board of education decision on the education of students in the science of evolution and cosmology," 1999; Benen, 2001; "Kansas evolution battle spreads to Kentucky, New Mexico schools.," 1999), or the reasons why evolution is the only theory which should be taught in the science classroom (Benen, 2001; "Support for Kansas board of education's decision to teach evolution," 2001). This study will be the first of its kind in looking at parochial school student and teacher attitudes toward evolution education.

Studies on teacher opinions on the teaching of evolution have been growing in number over the past twelve years. They are often linked to the particular state in which the study is conducted (Benen, 2001; Osif, 1997; Shankar & Skoog, 1993; Tatina, 1989; Van Koevering & Stiehl, 1989; Zimmerman, 1987). Each study has some form of survey from very short forms of six questions (Benen, 2001; Rutledge & Mitchell, 2002) to more extensive projects where the statistics of teacher beliefs were analysed against what teachers actually taught (Benen, 2001; Bilica, 2001).

This study will follow a similar look at opinions as well as looking into affective results of teaching evolution in the parochial high school.

The research will be done using a survey approach. This approach was chosen since the “distribution of variables... [are] difficult to observe... [and] the population under consideration is relatively large” (Crowl, 1996, p. 235). It is also appropriate since there has been little research on parochial schools and the teaching of evolution. This study will begin the compilation of data in this area of research. Finally, the interpretation of results will help define the many possible influences on this specific learning environment.

1.3 Statement of Purpose

The purpose of this study is first to investigate and explicate the emphasis placed on topics in evolution by parochial school teachers and second, to determine if students who are subject to a unit in evolution, change their attitudes toward the seven scales of science attitudes (Fraser, 1981). This continues research about teachers’ emphasis placed on evolution in their classrooms (Ayala, 2000; Bilica, 2001; Bilica & Skoog, 2002; Ellis, 1986; Osif, 1997; Shankar & Skoog, 1993; Skoog & Bilica, 2002; Tatina, 1989; Van Koevering & Stiehl, 1989). It also studies the change in students’ opinions of science because of instruction about evolution.

1.4 Research Questions

Studies have been done which analyse public school emphasis and teaching of evolution in biology classrooms (Ayala, 2000; Bilica, 2001; Bilica & Skoog, 2002; Ellis, 1986; Osif, 1997; Shankar & Skoog, 1993; Skoog & Bilica, 2002; Tatina, 1989; Van Koevering & Stiehl, 1989). These studies take the majority of their data from public secondary school classrooms. The goal of this study is to broaden the research field to include specific parochial school data as well. The research questions have been formulated to expand the scholarship in this area.

The research questions are:

1. Is the TOSRA a valid and reliable instrument for testing science attitudes of parochial school students in the United States?

2. Does exposure to evolution education change the science attitudes of Lutheran high school biology students?
3. To what degree do Lutheran secondary school teachers incorporate evolution in their teaching of basic first year biology courses?
4. What is the amount of emphasis given by Lutheran biology teachers to the seven fundamental concepts of evolution as compared to the amount of emphasis they would place on each concept given unlimited freedom to decide the curriculum?
5. How do Lutheran biology teachers compare to public school teachers in their emphasis of evolution education in their classroom and the influences which guide their decisions?
6. Do demographic characteristics of gender, years of teaching experience, age, highest tertiary degree held, completed tertiary biology coursework, location of tertiary work, state certification, or community setting influence Lutheran teacher emphasis on evolution?

1.5 Methodology

This study used a mainly quantitative approach to learning about the condition and effects of evolution education in the parochial school. The study incorporated two surveys, the Test of Science Related Attitudes (Fraser, 1981) and the Teaching Evolutionary Topics Survey (Bilica, 2001). These surveys were used to determine change in attitudes of students toward science and teacher emphasis and influences on evolution education.

The research participants consisted of all biology teachers currently teaching in Lutheran high schools in the United States, and 660 Lutheran high school biology students grades 9-12 in California, Nevada, and Arizona. The study was conducted during seven months of the 2003-2004 academic year between October 2003 and April 2004.

The Test of Science Related Attitudes (TOSRA) was used to determine if there is a change in student attitudes toward science after students participated in a unit on evolution in their secondary school basic biology class. This was done in a pre-test/

post-test design with a single intervention of a unit in evolution. Students completed the 70 question TOSRA within the week before the unit on evolution and another copy of the TOSRA within a week of finishing the unit on evolution. The student responses were then recorded and analysed using SPSS 12 to find the reliability of the instrument and significant variation between the two administrations.

The Teacher Evolutionary Topics Survey (TETS) was used to collect data on: teacher emphasis of the seven fundamental topics of evolution; eight scales of influence on teachers decisions for teaching evolution; demographic data of age, gender, years of teaching experience, highest tertiary degree held, completed tertiary biology coursework, location of tertiary work, state certification, and community setting; and qualitative free response comments from teachers. These data were recorded and analysed using SPSS 12. Reliability and validity of the instrument were analysed as well as relationships between the scales, emphasis data and demographics.

1.6 Significance of the Study

This study will broaden the knowledge from previous studies on emphasis given to evolution education by high school biology teachers and science related attitudes of students (Ayala, 2000; Bilica, 2001; Bilica & Skoog, 2002; Ellis, 1986; Osif, 1997; Shankar & Skoog, 1993; Skoog & Bilica, 2002; Tatina, 1989; Van Koevering & Stiehl, 1989). By surveying an underrepresented group, parochial school teachers and students, this study will extend the scope of evolution education research. This study will also determine if there is a need for a change in pedagogy to cause students to assume more positive attitudes in the seven categories of science thinking.

This study will be highly significant to a broad audience. My own interest is in furthering the effective teaching of evolution and creation in the Lutheran school system. A majority of students from these schools will attend public universities where they will need to know evolutionary concepts whether or not they accept them as their own personal belief. It is my goal in another study to find ways to effectively teach evolution and creation in the religious school. This study will be a springboard for that future investigation.

The participants in this study will be given the results of the study for their own learning. Science teachers are often isolated in their own classroom and either don't have the time or resources to visit with other teachers and dialogue about the classroom learning environment. This study will add to the knowledge of those teachers and allow them to reflect and compare what they do to what others in their field are doing.

This study will be a starting point from which other research can be done in this field. Future learning environment studies can look at the effectiveness of teaching styles in the subject area of evolution and creation. Intervention studies can be done to test different methods and or comprehension levels. Church leaders will be able to take an in depth look at the philosophy behind what is taught and compare that to their doctrine.

1.7 Limitations of the Study

The following limitations of this study are acknowledged.

This study is limited from generalization to populations other than Lutheran biology teachers in the United States and Lutheran high school biology students in the pacific southwest United States. The study group included all Lutheran biology teachers in the United States and students from Arizona, California, and Nevada.

This study is limited due to non-response from the selected population. The generalizability of the findings will be limited to people who willingly fill out surveys and return them. Survey non-participants will not necessarily be represented in the final outcomes. To overcome this teachers will be made aware of the study before a mailed survey is sent. This will help the teachers discern that participation is of high significance.

This study is limited due to the size of the sample population being a small portion of Lutheran high school biology students in the United States. This will be overcome by paired sampling analysis which is more definitive than random pairing analysis.

Church-school politics may also be limiting this study. Respondents may have a difficult time since some religious leaders condemn any teaching of evolution, and

respondents could possibly feel pressure to answer in ways pleasing to their administration. To minimize this possibility, questions will be asked using specific definitions such as macro and micro evolution which are less controversial. Subjects names will not be released in the publication. Surveys will be conducted so the anonymity of the teachers and students will be kept.

1.8 Overview of the Thesis

Chapter 2 contains the literature review relevant to this study. The review begins by tracing the history of the controversy over evolution education. It continues by describing the purpose of evolution education and the nature of science as seen through the various studies which have been done. This chapter also contains information on the Lutheran church which holds the teachers and students which are the subjects of this study. Finally, Chapter 2 explains the surveys which were used for the study.

Chapter 3 describes the methodology used for this study. It contains the research objectives and research methods utilized to gain significant information. The surveys used in this study are described in detail as are the case study populations. This chapter also illustrates the analysis used to organize the data.

Chapter 4 possesses the results of the statistical analysis of the study. The validity and reliability of the surveys is described in this chapter. This chapter also discusses the significant statistical data which were obtained and any correlations or changes in student opinions. This chapter also discusses the qualitative information found in the comments section of the survey.

Chapter 5 examines the data from Chapter 4 and through a discussion creates conclusions from that data. This chapter has a summary of all the findings and explains the contributions this study has for furthering evolution education. Implications and ideas for future studies are included in this chapter.

CHAPTER 2

Literature Review

2.1 The Importance of Evolution Education

One of the most often quoted phrases in evolution education is the title of an article by Theodosius Dobzhansky: “Nothing in Biology Makes Sense Except in the Light of Evolution” (1973). This mantra has been repeated by evolution advocates for years, and many articles concerning evolution have used this line in the opening statements (Cherif, Adams, & Loehr, 2001; Cobern, 1994; Farber, 2003; Linhart, 1997; Rutledge & Warden, 2000; Swarts, Anderson, & Swetz, 1994). The purpose of the statement is to solidify the argument that evolution must be taught in biology classrooms (Alles, 2001; Ayala, 2000; Blackwell, Powell, & Dukes, 2003; Farber, 2003; Good, 2003; National Association of Biology Teachers, 2004; Swarts et al., 1994; Zook, 1995). This is needed because “the teaching of evolutionary theory in public high schools has been embroiled in controversy throughout the century” (Rutledge & Warden, 2000, p. 23).

Alles (2001) states that the need to teach evolution comes from the research that says, “Science does not have unquestioned credibility with the American public, and as a result, we must demonstrate why science is credible” (p. 20). He goes on to show that integration of history and philosophy of science into biology courses can assist in such a demonstration. His study of biology 101 students and their perception of the topic of evolution led him to say,

The take home message from this experimental biology course is that a natural sequence to teaching biology exists, and from this natural sequence flows our understanding of the natural world. This insight, however, is useless if we do not at the same time make our students aware of the nature of science. This is the message of the National Academy of Sciences, and my experience has show that it is not only possible to use evolution as the framework for teaching biology, it is what we should do if understanding the natural world and ourselves is the goal of teaching biology. (Alles, 2001, p. 23)

“The theory of evolution needs to be taught in schools,” according to Ayala (2000, p. 31). He continues by saying,

Modern biology has broken the genetic code, developed highly productive crops, and provided knowledge for improved health care. Students need to be properly trained in biology to improve their education, increase their chances for gainful employment, and enjoy a meaningful life in a technological world. (Ayala, 2000, p. 31)

This stance demands that evolution be taught as the material explanation for the diversity of life around us. Ayala also says that science and religion explain two different realms so that teaching evolution in schools is another “way of acquiring knowledge about ourselves and the world around us, but it is not the only way” (Ayala, 2000, p. 31). In saying this, he continues the stance that evolution must be taught in schools.

Farber reiterates Ayala’s sentiments, saying that,

The theory of evolution, then, is impressive, productive, and important. To become a serious biologist, one needs to have a grasp of what evolution means, and to be an informed citizen, one should have a general understanding of what the theory claims. (Farber, 2003, p. 348)

Knowledge then becomes not only a need for explaining the world, but is a prerequisite for being a biologist, and no less for being a citizen of this world.

Farber (2003) also notes that it is important to understand how science deals with its claims of truth. There are categories of ideas based on how well they are supported with evidence. Words such as *law*, *facts*, *hypothesis*, and *theory* need to be examined in different lights; whereas facts are usually observable instances of reality, theories are complex evolving statements with complex explanations to large bodies of knowledge. The misunderstanding and misinterpretation of these words lead to semantic arguments about evolution being “only a theory.”

In the LSU Resolution on Teaching Evolution, Good writes, “teaching biology without evolutionary theory is comparable to teaching physical science without atomic theory” (2003, p. 514). This means that the teaching of evolution is absolutely necessary since it is one of the most basic tenets of biology. Good also notes, however, that “one must include adequate coverage of the role of religion has played in the development of the theory of evolution” (2003, p. 515). This is saying that the history of evolution is also key for good teaching in schools.

Zook (1995) demands that evolution permeate the life sciences curriculum. To do this, teachers must be trained and developed in the teaching of evolutionary theory. More funding must be given to research and to implement effective evolutionary teaching. He would also push that evolution be updated and re-evaluated in a professional collegial organization which would meet on a regular basis. Each of these things should be done to show how evolution is a key element of and basis for biology (Zook, 1995).

2.2 Educational Standards for Evolution

Educational standards have been developed by many organizations in the United States to help teachers know appropriate learning goals for their students in all subjects. Many standards for science have come from professional organizations, including the National Science Teachers Association’s *Scope, Sequence and Coordination Project* (1992), the American Association for the Advancement of Science’s *Science for all Americans* (1990) and *Benchmarks for Science Literacy* (1993), and the National Research Council’s *Science Education Standards* (1996). Each of these professional science organizations has helped shape the state science standards and local science standards for schools all over America. It is from these standards that the delineation of what parts of evolution should be taught in schools has come.

In an analysis of state science standards, Skoog and Bilica found eight emphasis dimensions for teaching evolution in schools (2002). These emphases included species evolving over time, speciation, diversity of life, descent with modification from common ancestry, evidence of evolution, natural selection, pace and direction of evolution, and human evolution. When looking at how these topics are discussed

in state science standards, they found that not all of the states included all of the dimensions of evolution.

Skoog and Bilica's analysis of state science standards reported differing emphases on the major topics of evolution (2002). In studying 49 states and the District of Columbia, (Iowa at the time did not have state standards for science), the researchers found that 92% of the states included the teaching of natural selection and species changing over time in their state science standards. This high percentage held for states teaching about the diversity of life with 90% of states covering that topic and 76% of the states including the topic of evidence for evolution. These highly emphasized topics can be contrasted with the low emphasis on speciation at 44%, descent with modification at 42%, pace and direction of evolution at 20% and human evolution at 7%. These results show that evolution should be taught in the public schools, but the curricula do not necessarily reflect a complete integration of all the major topics of evolution.

To study how well each state addresses evolution, the Fordham Foundation supported Lerner in grading each of the states and the District of Columbia (Lerner, 2000). This report gave a traditional school letter grade to each state on the perceived quality of evolutionary teaching as outlined by the state documents. The grade scale was from A to F, including the qualifiers of plusses (+) and minuses (-) with an "A" being a quality job and an "F" meaning failing. The results indicated that a third of the states were underachieving and two thirds were adequate or better in their teaching of evolution (Lerner, 2000). This study indicated that evolutionary science teaching is still in need of improvement.

In relation to the previous studies looking at the state level of standards, it is important to now look at what is being taught at the local level. Teaching is a relatively autonomous occupation where day to day teaching is not regularly supervised. This line of research on the emphasis teachers place on the topics of evolution in the classroom is rather young, beginning with Ellis (1986), but growing (Aguillard, 1999; Cherif et al., 2001; Ellis, 1986; Osif, 1997; Rutledge & Mitchell, 2002; Rutledge & Warden, 2000; Shankar & Skoog, 1993; Skoog & Bilica, 2002; Tatina, 1989; Van Koevering & Stiehl, 1989; Weld & McNew, 1999; White & Richardson, 1993; Zimmerman, 1987).

2.3 The Controversy Over Evolution Education

The reason for the high level of controversy and interest in the United States regarding the teaching of evolution in schools may be the idea of a perceived separation of church and state in the United States Constitution and the relatively recent founding of the country as a “God-fearing” nation. The description of creation in the Biblical (Genesis) account is a Judaic and Christian text. If this is provided in schools, the Establishment clause of the first Amendment to the United States Constitution would be violated. Abiding by the law requires the removal of creationism from the public classroom.

We can also see that many of the key creationist movement scholars are American (Bergman, 1993): Harry Rimmer, George McCready Price, Frank Marsh, Henry Morris, John Whitcomb, Dudley Whitney, Hugh Ross, Michael Behe, and Phillip Johnson. While this list is not exhaustive, there was not a large creationist movement outside of the United States until the late 1900’s.

Controversy regarding evolution seems to be well summed up by Blackwell, Powell, and Dukes (2003):

It is of course the question of the origin of humans that is the source of the most conflict when considering evolution. Related to this conflict is the vanity of the conception that we are somehow God-like, or closer to God than any other animals, i.e. that we humans are “special creations.” ...it is this creationist view that has played most emotionally against a naturalistic origin of humans through evolution.... (p. 64)

While creationists do not agree with the statement that vanity is the cause of their beliefs, this paragraph shows the bias and emotional rhetoric by which the discussion turns into argument.

Internationally, the topic of evolution education in the classroom is growing. In Canada, MacBain (2003) reports that the Canadian school and government officials are struggling with whether or not only evolution should be taught in schools. Downie and Barron (2000) embarked on a study of attitudes of Scottish first-year

biology and medical students since they felt that the establishment of statistics on attitudes would help them in their teaching of evolution and there were no studies they could find of this type in the United Kingdom. Zuzovsky (1994) likewise wanted to develop effective methods in teaching and worked with students in Israeli science classrooms. Some teachers are being detained by government officials for teaching evolution in Sudanese Universities (Holden, 1990). The topic of international textbook coverage of evolution is being studied as well (Swarts et al., 1994). There are also formal science groups in England, Korea, Turkey, and Russia which discuss evolution education from differing viewpoints (Bergman, 1993; Chapman, 2001). As the American influence on the world grows, the topic of evolution education develops.

2.4 The Legal Progression of Evolution Education in the Classroom

Evolution in the classroom is a phenomenon rooted in the writings of Charles Darwin. Although he was not the first person to theorize about evolution, he has been credited with being the “Father of Evolution.” This is due to his book “On the Origin of the Species” (1859) being the most reliable work about evolution up to that point. This book was followed twelve years later by his work “The Descent of Man” (1871) which added human origins to the controversy brewing over the ideas of evolution.

In textbooks, evolution was not held as a scientific principle until after the turn of the 20th century (Carpenter, 1963). Up to that point, scientists of the day found that the theory of evolution did not hold to their ideology of correct scientific method. The lack of belief in the theory of evolution led textbook writers to leave the theory out of texts. It was not until the early 1900’s that younger scientists who did see the credibility of evolution started to write texts published with evolution as a topic (Carpenter, 1963). This trend continued through the first two decades of the new century.

As textbooks became more inclusive of evolution, the controversy over its inclusion in public school education grew. In the 1920’s, state legislatures started to introduce laws that prohibited teaching evolution in the classroom. These laws have been tested within the judicial branch of government, and subsequently have been found to violate federal law.

The first state to enact an anti-evolution law was Oklahoma ("Amendment to House Bill No. 197," 1923). This law was not its own bill, but an amendment to another bill that would have made textbooks free to all students in the state. The amendment noted that "no copyright shall be purchased, nor textbook adopted that teaches the 'Materialistic Conception of History' (i.e.) the Darwin Theory of Creation versus the Bible Account of Creation" ("Amendment to House Bill No. 197," 1923). Although there was debate about attaching this amendment to a popular bill for free textbooks, the legislation was passed in the House and Senate to be signed within a month by the governor of the state (Larson, 1989).

Many more bills were introduced in state legislatures to ban the teaching of evolution in schools. Thirty-seven such bills were introduced, but not all were passed into law. Florida, in May of 1923, became the second state to enact an anti-evolution in the classroom law followed in 1925 by Tennessee (Larson, 1989). Although they were based on the principle of not requiring students to believe in evolution, the two state bills did have differences. The Florida law allowed the teaching of evolution so that students would know about the concept but did not imply that they must believe its truth. The "Butler Law" (so named after the author) in Tennessee did not allow the teaching of evolution at all ("House concurrent resolution No. 7," 1923). While the Florida law did not have criminal consequences if broken, the Tennessee law outlined punishment for violators ("House Bill No. 185," 1925). Eventually both laws were overturned in the courts. It was the Tennessee law that led to the most well known court case in the evolution debate, *Scopes v. Board of Education*.

Although it is not the original case dealing with evolution, *Scopes v. Board of Education* is probably the most famous case concerning evolution teaching in the classroom. Also known as "The Scopes Monkey Trial," the case concerned the defendant John T. Scopes who, in 1925, was charged with teaching evolution in his Dayton, Tennessee, science classroom. This was contrary to the Butler Law which disallowed the teaching of human evolution in the classroom (Randy Moore, 2000b). Scopes was found guilty of breaking the law. His fine, however, was the minimum allowed. This legal suit, on paper, was a victory for anti-evolutionists, but

the aftermath of the suit led to creationist teachings being removed from schools in the subsequent cases.

The monkey trial was the test ground for the constitutionality of anti-evolution legislation. The American Civil Liberties Union (ACLU), an organization that challenges any governmental regulations which may inhibit the freedoms of citizens, defended Scopes in this case in order to show that anti-evolution laws were unconstitutional because of the amendment for free speech. They also initiated the debate we see today for the separation of church and state. Clarence Darrow was chosen by the ACLU to defend Scopes and to show that anti-evolution legislation was unconstitutional (Larson, 1989).

William Jennings Bryan was called upon by the World's Christian Fundamentals Association to be the prosecutor in the Scopes case. Bryan, who was a four-time presidential candidate, was chosen because of his outspoken Christian fundamentalism, charisma, and popularity with average fundamentalist citizens of the time. His goal was to make evolution the scapegoat for many of the social problems of the day. In essence, as prosecutor, he was fighting on behalf of God against the evil of evolution.

After the Scopes trial was decided in favour of the prosecution, more states passed laws against the teaching of evolution. Mississippi passed House bill #77 which banned the teaching of evolution in 1926. Arkansas passed an anti-evolution law by popular vote of the state citizens in 1928. Other local rulings were also passed during this time along with additional states jumping into the fray by creating their own legislation. Finally, in 1929, Texas passed the last state anti-evolution act. At this point the fervour died down and very little was said or done about evolution in schools until the 1950's (Larson, 1989).

A renewed interest in science education created the atmosphere for a legal battle to revoke anti-evolution legislation. The United States' technological dominance had been usurped in 1954 by the Russian space agency at the launching of the Sputnik orbiter. This prompted American government officials to call for increases in science spending, and in the process, to rewrite or create new science textbooks (Grobman, 1969). Evolution was inserted without much opposition into this new

group of textbooks. Scientific ideas and methodology were being accepted by the public, and evolution had a place to stand in the new science consciousness (Larson, 1989).

A few years after the infusion of money into science programs, Susan Epperson, an Arkansas biology teacher, was the plaintiff in the case that brought the evolution debate back to the limelight. Epperson's complaint was that she wanted to teach evolution in her classroom since it was part of the newly adopted textbook for her class. She felt that not being able to teach about the evolution section of her book constituted an assault on her right to freedom of speech. "...the Supreme Court [of the United States], in 1968, decided *Epperson v. Arkansas*, which prevented states from out-lawing the teaching of evolution" (Shaver, 2003, p. 399). This case set the precedent for many others that came to court over the next few decades.

The Epperson case broke ground for the repeal of anti-evolution laws in every state. Tennessee's House of Representatives passed a bill to revoke the state anti-evolution law. In a bizarre course of events, the state Senate did not pass that bill while within the same week a teacher, Gary Scott, was brought up on charges, which were later dropped, of teaching evolution in the classroom (Larson, 1989). Again the ACLU, along with other organizations including the National Science Teachers Association, American Association for the Advancement of Science, and the National Education Association, protected the rights of Gary Scott's free speech. Now under pressure, the state Senate reviewed the anti-evolution law repeal and passed it, allowing the governor of the state to sign the bill into law.

Every state started to follow suit, striking down anti-evolution laws with Mississippi being the final state to repeal anti-evolution legislation. In 1969, Mrs. Arthur Smith sued the state for its law against evolution on the grounds that it was denying her daughter the freedom to learn. This argument focused on the idea that students should have the freedom to hear about different non-religious explanations for biological beginnings. The reasoning for the case was based on legal precedent. After an initial dismissal of the case in lower courts, the Mississippi State Supreme Court ruled that the anti-evolution law was unconstitutional on the basis of the *Epperson* case in Arkansas (Larson, 1989).

At the point of the repeal of the last anti-evolution law, anti-evolutionists changed their tactics: instead of trying to remove evolution from school curriculum, they attempted to include creationist ideas in science classes (Numbers, 1982). This strategy played out as a grassroots effort in its beginning before moving into legislative wrangling. At the forefront of the new attack on evolution in schools were Henry Morris, Nell Segraves, and Kelly Segraves. These dedicated creationists heavily promoted the new efforts through the Creation Research Society and Creation-Science Research Center. Their research is still ongoing.

Wright v. Houston Independent School District was the first of three cases to ask for and be denied equal time for competing theories to evolution. In this case the mother of Rita Wright wanted to sue the school for teaching evolution as a fact without giving mention to any other theories. This was struck down before the case went to trial with the judge declaring that it wasn't for the courts to decide which theories would be taught in schools and which theories would not be ("Wright v. Houston Independent School District," 1972). This upheld the *Epperson* decision and made teaching theories other than evolution in science classrooms untouchable to anti-evolutionists.

The cases of William Willoughby against the National Science Foundation (NSF) and Dale Crowley against the Smithsonian Institute were decided in much the same way as the *Wright* case (Larson, 1989). In 1972, Willoughby wanted the NSF to withhold funding of a pro-evolution book by the Biological Science Curriculum Study (BSCS) since it did not address creationist issues. In 1974, Crowley wanted equal time for theories other than evolution to be presented in a Smithsonian museum exhibit on origins. Each man was trying to say that the government was furthering atheistic naturalism, a religious position which concurs with evolution. Each case was dismissed on the grounds of the *Wright* decision discussed in the previous paragraph.

Although the courts consistently approved evolution in the classroom in previous decisions, a victory for the proponents of creation in the science classroom came in California in the adoption of the California State Science Frameworks. In 1970, the Science Framework included creationism and evolution as equally necessary theories of origins. Inclusion of creationism was found to be inappropriate in the

Frameworks, but then the attack by creationists led to the consideration that focusing on evolution as the only possibility of origins would infringe on religious beliefs. Kelly Seagraves used this rationale in his case *Seagraves v. California* he did not want his child to be subjected to being told that belief in creation was wrong in light of evolution. This particular case ended, according to Larson (1989), as being called a victory by both sides. The State Board claimed to fend off a creationist attack (since creationism was not subsequently included in the curriculum) and Seagraves emphasized that because of the Free Exercise of Religion clause of the First Amendment of the United States Constitution, science teaching must accommodate religious beliefs. These interpretations helped the creationism proponents since science was no longer the sole force behind curriculum decisions.

At this point in time, twenty-four creationism bills were introduced in twelve different states from 1971 to 1977 (Wilhelm, 1978). In 1973 the first bill to become law was in the evolution-battle-torn state of Tennessee. The bill was initiated to say that all origins explanations needed to be labelled as theories. This bill had several amendments that were used to try to unseat evolution as the only valid explanation for the current state of the biological world ("Senate Bill No. 394," 1973). The first amendment to the bill was that the Genesis account was to be labelled as a fact rather than theory. Second, the Genesis account was the only one in particular to be included with evolution. Finally, occult and satanic beliefs were to be excluded from the texts. Additional amendments to the bill then allowed presentation of supplementary theories through supplementary materials rather than the basic text. Even with these anti-evolution sentiments, the House and Senate both passed the bill which became law since the governor of the state did not act upon it before the passage deadline (Larson, 1989).

This Tennessee law was soon challenged in the courts and declared unconstitutional. Two cases, *Daniel v. Waters* and *Steele v. Waters* showed that such a law was a violation of the Establishment clause in that preferential treatment was given to the Genesis account. It also showed that banning occult and satanic beliefs was censorship (Larson, 1989). These cases struck a blow to the establishment of creation science in the Tennessee classroom, but other states were still working through the legislation.

In Texas and Kentucky, legislation that would avoid the pitfalls which caused the Tennessee law to be nullified was being formed. The Texas State School Board wrote into their education code that evolution was to be taught as theory and that any textbook must identify evolution as only one of many competing theories on origins ("Texas Education Code Annual," 1974). In Kentucky, a bill was passed that did not force teachers to stop teaching evolution, but allowed them to teach the Genesis account if they so chose. In each case, they avoided the court repeal based on the Tennessee precedent because neither legislation disallowed the teaching of evolution in its entirety (Larson, 1989).

The Indiana Textbook Commission took a different approach to allowing for alternative views to evolution in schools. In selecting textbooks which would be authorized for use in the state, the committee chose one biology text that supported the creationist perspective toward origins rather than the evolutionary perspective of the other six adopted texts. When some of the districts chose the creationist text, the ACLU stepped in and sued with a student, Jon Hendren, as the plaintiff. The case *Hendren v. Campbell* was again based on the Establishment clause saying that the school had no right to establish religious education in a public school (Larson, 1989). As a result of the case, the state textbook commission eliminated the text in question from the list of acceptable books.

While these court cases were taking place, a law student name Wendell Bird was working with Henry Morris of the Institute for Creation Research (ICR) to draft what could be used as a resolution in legislative houses for the inclusion of creationism in science classrooms (Randy Moore, 2000a). The terminology, however, was changed from "creationism" to "creation science" in order to remove the idea that this was promoting religion rather than science. This change was to make the resolution more palatable to the courts who had shown previously that putting religious argument toward teaching anything but evolution was not constitutional. The resolution was then distributed by ICR across the nation and picked up by many legislators (Larson, 1989).

Both Arkansas and Louisiana passed short-lived "equal time" bills based on the Wendell Bird-Henry Morris resolution to allow creation science to be taught with evolution. The Arkansas bill was signed into law by Governor Frank White in 1981

(Brummett, 1981). The Louisiana bill was also signed into law that year by Governor David Treen (LaPlante, 1981). Although these bills seemed to be a victory for creationists, future legal challenges saw their demise.

McLean vs. Arkansas Board of Education reversed the Arkansas equal time bill. In this case, the ACLU again was championing the issue of separation of church and state put forth by the Establishment clause of the United States Constitution. In this case, the ACLU based their argument on the idea that creation science was not science at all. They said that the purpose of giving the creation science name was to hide the fact that the concept was based on the Judeo-Christian origins explanation of the Bible. The judge, William Overton, found that the bill was unconstitutional since creationism in his opinion was unscientific. He felt that creationism was not based on scientific principles and that the people who were proponents of creation science were not legitimate scientists and therefore couldn't authoritatively pronounce that creation science was truly science (Randy Moore, 2000a).

The well known *Edwards v. Aguillard* case of 1987 looked at the issue of the "Louisiana law that mandated the teaching of 'creation science' along with the theory of evolution in public schools" (Shaver, 2003, p. 400). In this case Don Aguillard, a high school biology teacher, was resisting the idea that creation theories should have "equal time" in public biology classrooms. He felt that being forced to teach creation science went against his First Amendment rights and the separation of church and state. In their decision, "the U.S. Supreme Court ruled that Don Aguillard did not have to teach creation science in his classes" (Randy Moore, 2000a). This case followed the precedents of the *Epperson* and *McLean* cases which showed that religious based doctrine should not be taught within the science classroom. This case was considered a huge set-back to proponents of creation ideas being taught in the public classroom.

There are a number of other smaller law cases in the lower courts which have battled the "evolution in the classroom" issue. These cases deal with the finer points of law where anti-evolutionists tried to skirt laws about teaching creation or not teaching evolution as a well supported theory.

Disclaimers regarding the “validity” of evolution were addressed in *Freiler v. Tangipahoa Parish Board of Education*. The issue was that these disclaimers were actually written on the textbooks. “... the Fifth Circuit held that the disclaimer constituted an establishment of religion and was therefore a violation of the First Amendment” (Shaver, 2003, p. 402). This case focused on the use of a written disclaimer on textbooks which would state that evolution was not a fact. The purpose was to discredit evolution. This fits with the anti-evolutionist jargon of “it is just a theory.” The court ruled in favour of those who did not want the disclaimers.

In *LeVake v. Minnesota*, a biology teacher felt that teaching evolution should include instruction in the critiques of evolutionary theory (Tyrangiel, 2000). Having done so, the teacher was reassigned to different teaching duties where evolution would not be part of his assigned curriculum. LeVake felt this was a denial of “his rights to free exercise of religion, free speech, and due process” (Shaver, 2003, p. 403). Ultimately the court said the district had the right to reassign, but did not exactly address the idea of whether teachers could critique evolution in their teaching.

The right to critique evolution in the classroom was decided in *Peloza v. Capistrano*. This case, which was dismissed before entering the courts, was a specific challenge in saying that Peloza should be able to use his right of free speech at school to tell about his creation related religious beliefs. The case was dismissed as the judge said,

... the school board has the power to establish the curriculum. That is, a teacher has a contractual duty to follow the curriculum the school board sets, and the Free Speech Clause does not empower a teacher to override the board’s control of the curriculum by expressing beliefs that conflict with the curriculum to students during the school day. (Sendor, 1992, p. 5)

Each of these cases, although in lower courts, has established the interpretation of the law regarding the teaching of evolution in schools.

The courts are not the only place for debate. The schools and districts have also made rulings regarding evolution education (Randy Moore, 2000b). In Oklahoma,

before disclaimers were shown to be illegal, the state textbook committee required “publishers of biology books to post an evolution disclaimer in public school texts” (“Oklahoma attorney general issues ruling against evolution disclaimer,” 2000, p. 15). Texas has also had a lobby to vote down currently adopted textbooks in favour of books with less evolution (Gold, 2003a, 2003b). In Pennsylvania, the language of the state curriculum standards was changed to reduce the amount of emphasis of evolution in 2001 (Benen, 2001). New Mexico revised standards to make sure “to include evolution and related concepts, such as the age of Earth” (Thomas, 2000, p. 5). In Colorado, the Poudre School district ruled that a charter school is in breach of contract if teaching of human evolution is not included in the curriculum (“Colorado a victory for science,” 1999). California’s “Roseville Joint Union High School District... decided that they will leave the matter up to each school to decide rather than forming a district-wide policy” (Rosen, 2003, p. 21). In Georgia, the state schools superintendent, after eliminating evolution from the proposed science curriculum, reversed her decision based on queries from state scientists, educators, and parents (E. Barry, 2004). Interestingly enough, in 2000 “only 31 states in the US officially require high schools to teach students about evolution” (“Charles who?,” 2000, p. 5). This means that there is still a large arena where this discussion will play out.

The biggest case of wrangling in recent memory for evolution education came

... in August of 1999, ...the Kansas State Board of Education passed its state science education standards. Against the recommendations of a committee of 27 scientists and teachers, the board voted to strip from the standards all mention of the Big Bang, the age of the Earth, and any reference to organisms having descended with modification from common ancestors: in other words, evolutionary astronomy, geology, and biology. Teachers were informed that evolution would not be included in the state high-school assessment exams, greatly decreasing the likelihood that the subject would be taught. (Scott, 2000, p. 813)

The aftermath of this decision was a quick battle of statements on teaching by various science associations demanding that evolution be reinstated in the standards.

The American Association for the Advancement of Science (AAAS) was a big contributor to the reversal of this decision when they put out their "Statement on the Kansas State Board of Education Decision on the Education of Students in the Science of Evolution and Cosmology" ("AAAS statement on the Kansas state board of education decision on the education of students in the science of evolution and cosmology," 1999). This resolution "urges the citizens of Kansas to restore the topics of evolution and cosmology to the state curriculum. AAAS stands ready to assist all concerned citizens of Kansas in securing the repeal of this damaging ruling by the State Board of Education" ("AAAS statement on the Kansas state board of education decision on the education of students in the science of evolution and cosmology," 1999, p. 1754). In addition to this statement, statements were made by many groups supporting the overturn of the evolutionless science standards. The presidents of the American Association for the Advancement of Science, the National Academy of Sciences and National Research Council, and the National Science Teachers Association released a statement praising the Kansas board for their new document which "embraces modern science and is consistent with national efforts to improve science education" ("Support for Kansas board of education's decision to teach evolution," 2001, p. 163).

2.5 Teachers' Knowledge of the Law and Evolution

Moore (2004) has shown that current biology teachers do have knowledge of the law and legal proceedings regarding teaching evolution in schools; however, many are still misinformed. In a study of Minnesota biology teachers, Moore used a survey based on the most common questions about legal issues associated with the teaching of evolution. The survey's questions related directly to court decisions discussed previously. While a majority of teachers knew facts, including that "they are not required to give equal time to creationism [and] the first amendment does not entitle a science teacher to teach creationism," there were still misunderstandings such as teachers thinking that they can give creationism equal time (Randy Moore, 2004, p. 861). Moore encourages continuation of teacher training to address the lapses in understanding of the legal precedents.

2.6 Goals of Teaching Evolution

What is the goal of teaching evolution? This question has been addressed by researchers with differing results, in part because of the definitions of the words “understanding” and “belief.” Smith makes this point:

... belief in evolution is ill-advised on several grounds, principally because students may understand the term belief as synonymous with faith, opinion, or conviction and not as equivalent to the scientist’s meaning of the word acceptance.... Understanding the basic premises of various theories of evolution (eg., Lamarckian, Darwinian, neo-Darwinian) is in fact not the same as choosing which of these competing theories to accept as the most valid explanation of the available evidence. (1994, p. 594)

This means that the educational goal of an instructor must be narrowly defined as either trying to change beliefs of students or adding to understanding as Smith has purported. This aligns with Clough’s thought that we should “stress functional understanding rather than belief” (1994, p. 411).

Moore also shows that definitions aren’t relegated to terms, but ways of speaking about a topic. He says that “... students fail to distinguish between the relatively concrete register of genetics and the more figurative language of the specialist shorthand needed to condense the long view of evolutionary processes ... there is a need ... [for] attention to the languages of evolutionary theory as an integral component of the evolution curriculum” (Rob Moore et al., 2002, p. 69). So as science teachers, we need to teach the terminology and methodology of the evolution curriculum.

A perspective important to this study dealing with Lutheran students is that of the Lutheran instructor who has to deal with the Church position on the topic of evolution. Because biology teachers in the parochial setting may not believe in evolution, they could be influenced not to teach about it, regardless of their background in biology. Fysh and Lucas imply that it is necessary to teach about science and mandate that

Science programs in a Christian school should seek to integrate understanding of science with life experiences, values, and faith of the student. Offering science in a way that denies or at least ignores these other dimensions is counter to the central reason for such a school's existence....Science teachers who show sensitivity and respect for student beliefs in the classroom will help their students learn tolerance, have confidence in themselves, and also a measure of appreciation for the complexity and interrelatedness of the universe. (1998, p. 67)

This perspective has the goal of teaching students about science, and within that, evolution, as well as other life experiences.

2.7 Pedagogy and Evolution Education

To teach evolution effectively, it is important to look at the nature of science. It is also "...necessary that those teaching evolution (or any science) have an adequate conception of the nature of science if they expect to teach their students effectively" (Farber, 2003, p. 349). This belief has been heralded by both the American Association for the Advancement of Science (American Association for the Advancement of Science, 1990, 1993), and the National Academy of Sciences (National Academy of Sciences, 1998). Zook (1995) is bold to foster the idea that "conference gatherings must be willing to self-educate in key aspects of evolution as part of their agenda... Otherwise, science educators run the risk of, at worst, being part of the problem rather than the solution..." (p. 1114). Cherif, Adams, and Loehr concur with these thoughts and feel as though "We need to expand our teaching... teaching the nature of science at the grass roots level to parents, senior citizens and religious groups in their local settings" (2001, p. 569). As Farber continues on the same line regarding the traditional way to teach evolution, by presenting evidence for evolution and implying that "there is so much evidence for the theory it must be correct, and by implication, only an obscurantist or religious fanatic would go against all that evidence" (Farber, 2003, p. 349), we must look at the negatives to that approach. He sees the problems with the approach as not only "... dauntingly dogmatic, but also static" (Farber, 2003). This is a serious concern for biology teachers. If teachers want to be effective, they must combat the lack of knowledge

about the nature of science and the nature of religion (Good, 2003; Passmore & Stewart, 2002; Rudolph & Stewart, 1998; Rutledge & Mitchell, 2002; Zuzovsky, 1994). As educators it is possible to accomplish this task through innovative pedagogy.

Different studies have addressed the issue of how to teach evolution effectively. Lawson (1999) says to use a scientific approach to the matter where students will engage in scientific reasoning skills such as “raising causal questions...considering the major alternative explanations that have been proposed... deducing predictions (expectations) based on the assumed truth...gathering evidence... [and] comparing evidence” (p. 266). This would fit in with Posner’s (1982) conceptual change theory where students would take their old ideas and restructure them based on new ideas and experiences. Other pedagogical designs have included the epistemological approach (Zuzovsky, 1994), laboratory exercises (Winterer, 2001), law-related education (Morishita, 1991), geological comparison (Cherif et al., 2001), comparison of models of evolution (Passmore & Stewart, 2002), readings and discussion (Scharmann, 1993) and concrete activities (Keown, 1988). Matthews goes as far as saying that incorporating creation stories from students’ beliefs into the curriculum will help cause conceptual change (2001). Whatever the way we teach for effectiveness, it is important that we know the goal.

Rudolf and Stewart (1998) caution the science teaching community that in the teaching of evolution, knowledge can only be achieved through use. They say that

Scientific theories ... are constructed by the scientific community precisely to fill the dual role of explanation and exploration to make sense of what is known and to guide future inquiry. Science instruction that ignores the latter function significantly handicaps student understanding.... Conceptual understanding comes not from mere knowledge acquisition, but rather from the instrumental use of knowledge as a means to an end. Thus, the validity of Darwin’s model cannot be passively demonstrated for students, but can only be fully realized in use. (p. 1085)

This mandate needs to guide how evolution is taught in the schools.

Textbooks have been shown to address inadequately the topic of evolution as compared to other common biology themes. In a survey of fifty commonly used biology textbooks, Linhart found that “textbooks... fall short of the baseline definition [of evolution]” (1997, p. 387). This adds to the lack of proper pedagogy in evolution since many instructors rely on textbooks for much of the dissemination of information in their classes. Alexandre concurs by revealing in a study of textbooks in Spain that “If texts can be considered as an indicator of teaching, it would follow that the instruction reported here cannot promote functional learning in the majority of students” (1994, p. 532). Jefferey and Roach (1994), in looking at protoconcepts for creating the structure of knowledge in students’ minds, showed that elementary and middle school texts don’t address the understructure needed for students to grasp the concept of evolution. Students are not likely to understand evolution since what they read in the text doesn’t build their thinking skills in that direction. In a study of texts from Russia, China, and America, Swarts and others (1994), found that while American texts could do better in teaching evolution, the Chinese textbooks were even further behind in their addressing the issue. The Russian textbooks were lauded as superior in addressing the topic (Swarts et al., 1994). So not only is there controversy in the teaching of evolution, there is debate on the textual portrayal of the subject.

2.8 The Nature of Science

Science “deals with the natural world and, consequently, its explanations must be couched in natural expressions” (Clough, 1994, p. 412). This naturalistic viewpoint automatically “assumes the entire realm of nature to be a closed system of material causes and effects, which cannot be influenced by anything from the outside” (Johnson, 1993, p. 116). The National Academy of Sciences confirms this in their statement that “only evolution should be taught in science classes because it is the only scientific explanation of why the universe is the way it is today” (1999). This coincides with Ayala’s statement that “Science seeks material explanations for material processes, but it has nothing definitive to say about realities beyond its scope” (Ayala, 2000, p. 31). This then assumes that there cannot be any supernatural influence on the way the world works. This, of course, is what sparks the controversy since this contradicts the religious viewpoint of a god who is outside of this natural world coming into it and influencing the natural processes which are

determined through science. Science and religion are assumed to be at odds with each other concerning the creation of the diversity of life on earth and ultimately its origins, because both science and religion have seemingly conflicting viewpoints on each subject.

Rudolph and Stewart (1998) show that within science there are competing models of science research. The first is nomothetic research where "...the goal of inquiry is the accurate establishment of laws, or universal mathematical statements" (Rudolph & Stewart, 1998, p. 1076). This type of research is the foundation for discovery in physics. The second model of science research is historical which focuses on genealogical relationships as we see established in much of evolutionary theory. The difference between the two is important since manipulations of evidence for evolution are difficult to achieve, and this makes necessary the reliance on creating relationships that are logically valid, but not empirically testable. Both methods are valid, but historical methodology relies more heavily on indirect evidence, which is more difficult to validate.

Evolutionary science is typically validated using historical practice. Evidence from the fossil record in creating relationships between organisms is important to the study. While it is possible to work with living organisms and the processes of natural selection, the most controversial subjects of human evolution and beginnings are not easily manipulated. Popular opinion of the nature of science investigation does not parallel this need for non-nomothetic discovery.

2.9 Psychological Factors Influencing Teacher Attitudes Toward Evolution Education

Self-efficacy plays an integral role in teaching behaviour and decision making (Bandura, 1977, 1986, 1997). "Efficacy involves a generative capability in which cognitive, social, and behavioural subskills must be organized into integrated courses of action to serve innumerable purposes" (Bandura, 1986, p. 391). Teachers of biology courses must work through this paradigm to deal with teaching evolution. Teachers assess the information they know about the topic and their pedagogical skill and form the approach they will use to teach their classes.

Bandura (1997) notes that self-efficacy as applied to teaching is Personal Teaching Efficacy (PTE). PTE is the tendency to avoid tasks and situations which are perceived by teachers to be beyond their personal capabilities. The opposite would be true as well in that people would undertake tasks at which they feel proficient. Teachers with a low PTE may try new methods of teaching or broach difficult subjects, but when rebuffed by obstacles or failure, they soon give up. The teacher with a high PTE may encounter the same difficulties as a low PTE teacher, but the response to the difficulties would take the form of problem solving and creating new strategies to overcome the complications. This social theory serves as a sound basis for the study of teacher attitudes regarding the teaching of evolution.

Based on her research and supporting literature, Helms (1998) created a model of identity shown in figure 2.1 which can explain Bandura's ideas of PTE and how they relate to outcomes in teaching. There are four dimensions involved, including "actions; institutional, cultural, and social expectations, or what people think others expect; values and beliefs; and where these people see themselves going, or the kind of people they want to become" (Helms, 1998, p. 829). Within this model, there are links between what a person believes and his actions, but that link is not absolute. There is also a link between what a person believes and what others expect or value. This link is also not absolute. Finally the link between what a person thinks that others expect from actions taken will influence decision making. None of the links cause absolute direct decision for the self, but all contribute to how the person will conduct himself.

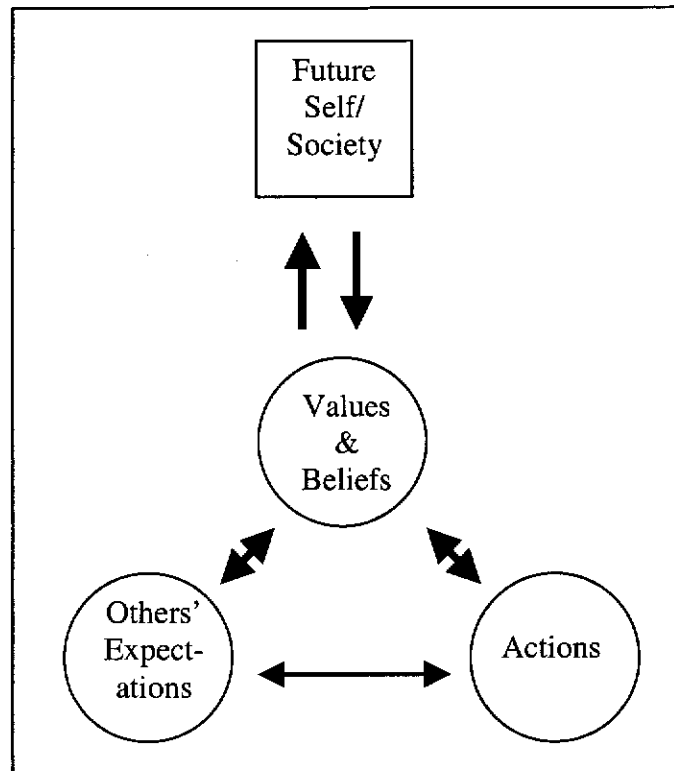


Figure 2.1. Helms model of identity.

The application of Helms's (1998) research to the context of the biology teacher teaching evolution, shows that there is an important link between one's beliefs and actions as well as a link between the perception of what others think and expect of one's actions. Teachers will emphasize evolution to the degree that they believe that teaching it is necessary (in their own opinion) as well as in taking account of how others would feel about the amount and approach taken to the teaching of evolution. The constituency of others in the case of the biology teacher would include students, parents, other teachers, administrators, school boards, state school boards, and professional organizations. In this stratified context, the teacher's decisions become quite qualified to appease the inner self as well as the constituency.

Ost (1995) shows that "personal and social values can conflict with empirical knowledge" (p. 140) In teaching evolution, some teachers may believe fully in the theory and its evidence and want to teach it to students, but choose not to because of parental or administrative pressures. Ost (1995) defines the four factors that play into this decision making process:

1. The need to base decisions on information that is politically correct
2. The drive to select data that are in support of predetermined decisions

3. An ignorance of, or insensitivity to, the implications of the empirical knowledge
4. A lack of confidence in or understanding of the empirical data. (p. 141)

Although all these factors play a role in decision making, the amount any particular factor influences a person's choices is not known.

It has been found that teachers will teach about evolution based upon how much they are willing to deal with the controversial subject. Meadows, Doster, and Jackson found that "managing the conflict between religious beliefs and evolutionary concepts is a highly personal process" (2000, p. 106). Teachers are going to teach evolution in a way in which they feel comfortable. Carlesen (1991) and Monsour (1997) show that lack of knowledge plays into their comfort level and ability to teach the subject. Some teachers in their dealing with the subject "try to avoid in-depth discussions of ... evolution." (Randy Moore, 2000b, p. 19). They cite retribution as one cause: "if I say the wrong thing, I could be looking for another job." (Randy Moore, 2000a). "Nellie Shelton, a biology teacher at Danville High School, said evolution is not taught in many Kentucky public schools. 'A lot of biology teachers don't touch evolution'" ("Kansas evolution battle spreads to Kentucky, New Mexico schools," 1999, p. 17). In the Moore article, another teacher is quoted with similar sentiments: many biology teachers "don't want anything to do with the word evolution." (Randy Moore, 2000b, p. 19). These responses fit with what Weld and McNew (1999) found in that evasion of the topic can be from fear of retaliation by parents and administrators. Whatever the reason for teaching or not teaching evolution, teachers ultimately are left to make their own decision as to how much emphasis they will put on evolution in their classrooms.

2.10 Studies of Teacher Attitudes Toward Evolution Education

Studies of teacher attitudes and coverage of evolution usually focus on public school teachers in individual states. Tatina (1989) found, in comparing teachers in South Dakota to teachers in previous studies by Zimmerman (1987) in Ohio and Ellis (1986) in Kentucky, that coverage of evolution was highest in Kentucky at 91%, followed by Ohio at 87.7%, and finally, at 72.9% in South Dakota. Aguillard (1999), who is well known for winning the court case in *Edwards v. Aguillard*, profiled Louisiana biology teachers in which "77 percent reported moderate to

strong emphasis for evolution instruction” (p. 184) This is higher than the 66 percent of teachers in Oklahoma who reported a moderate to strong emphasis in the study by Weld and McNew (1999). Osif (1997), working in Pennsylvania, found that “67.7 percent of the teachers agreed that evolution is central to the study of biology” (p. 555). Shankar and Skoog (1993) found that a lower number of Texas biology teachers, only 47 percent, found evolution to be a central theme. “Significant relationships were found between teacher acceptance of evolutionary theory and both teacher understanding of evolutionary theory and teacher understanding of the nature of science” in Rutledge and Warden’s (2000, p. 28) survey of Indiana public high school biology teachers. In a follow-up study, Rutledge and Mitchell found that “43% of teachers characterized their teaching of the topic as avoidance or brief mention” (2002, p. 25). Van Koevering and Stiehl saw that only 30 percent of Wisconsin biology teachers “actually commit themselves to promoting either evolution or creation as the only explanation that is supported by scientific evidence” (1989, p. 202). These studies focus on specific geographic areas whereas this study has looked at national perspectives.

The conclusions from studies on teacher attitudes show many similarities. Tatina (1989) found four trends in attitudes toward teaching evolution by South Dakota teachers. The first trend was the avoidance of evolution because of the complexity of the topic. This trend is bolstered because teachers may be covering the topic of evolution without a clear understanding of it. The second trend was that evolution is not covered because teachers do not believe in the validity of the theory. The third trend is that evolution is not covered because it threatens religious beliefs. Finally, Tatina (1989) found that pressure to include evolution in the biology classes was not common. There was actually more pressure not to include evolution in the curriculum. Each of these trends was corroborated by the findings in the study on Ohio teachers by Zimmerman (1987).

Aguillard (1999) describes similar conclusions to Tatina (1989). There is a “...positive correlation between teacher emphasis on evolution and college semester hours in biology and number of college courses in biology specifically dealing with evolutionary theory” (Aguillard, 1999, p. 188). This fits in with the idea from the previous paragraph where teachers may not teach evolution because they do not

have the training to know the nuances of the subject. Aguilard also corroborates the idea that there is not pressure placed on teachers to teach evolution and its value as a core idea of biological science. Aguilard does add the note that better methodology must be used in the coverage and teaching of evolution and that teacher training is the key (1999).

Rutledge and Warden (2000) took a deeper look at teachers' understanding of evolution, their understanding of the nature of science and their acceptance of evolutionary theory. The survey of three scales encompassing twenty questions per scale, which had greater breadth than previous surveys, showed a continuing trend regarding teachers and evolution. This study confirmed the lack of understanding and belief in evolution by teachers found in previous studies. This particular study showed that Indiana teachers only had a moderate level of acceptance toward evolution as well as understanding of evolutionary theory and the nature of science.

Because teachers are de-emphasizing the teaching of evolution in classrooms or ignoring its implications for biological science, each of the researchers in the previously discussed studies have emphasized a need for specific teacher training in evolution. Aguilard (1999), Rutledge and Mitchell (2002), Rutledge and Warden (2000), and Tatina (1989) all discuss the need for more hours of specific evolution training to increase the amount of evolution taught in the classrooms. This issue must be examined in the universities that train and credential science teachers.

2.11 Student Attitudes Toward Evolution Education

Considerable resistance from students, dependant on their beliefs, has been found when looking at belief in evolution as opposed to understanding. Downie and Barron found that "Acceptance of a literal religious creation account was the principal reason for rejecting evolution..." and that "...rejection of evolution correlated strongly with religious belief" (2000, p.139). In this study of Scottish first-year biology and medical students, rejectors of evolution made up 86% of the study population. This study also found a small number of students who rejected evolution because of perceived conflicts and contradictions. Students who did not reject evolutionary theory usually did so due to a lack of a better alternative theory. These results have been corroborated by other studies.

Evans (2001), in looking at students living in Christian fundamentalist school communities, found a similar connection between rejection of evolution and beliefs. This study compared the responses of students in fundamentalist communities and those in non-fundamentalist communities to a survey on origins. Rarely did fundamentalists accept the naturalistic view of evolution at any age while non-fundamentalists did have variation dependent on age (younger non-fundamentalists being less accepting of evolutionary theory) (Evans, 2001).

Other small studies continue to show that students' understanding of evolution and their beliefs create internal conflicts. In a small study on college students, McKeachie, Lin, and Strayer saw that "students entering the course [on evolution] with creationist beliefs must experience cognitive dissonance. Some of them resolved the dissonance by dropping the course" (2002, p. 192). Esbenshade (1993) also found the conflict in high school students. Seventy-six percent of the students Esbenshade surveyed "perceive a weak backing of religious belief by [evolutionary] theory" (1993, p. 335). In the same study looking at students with a strong science interest, "62% expressed the sense that there was a weak acceptance of theory by their faith" (Esbenshade, 1993, p. 335). The result may just be a disconnect for students, but Esbenshade feels that we may lose future scientists since 69% of the students he surveyed said that their faith could influence their decision to pursue a career in science.

Sandoval and Morrison (2003) reveal that students' ideas about the nature of science and attitudes don't change over the course of an intervention unit on evolution. In the small study, the researchers used the "Nature of Science" interview as a pre-test and post-test means of comparing attitudes the students had about science before and after a four-week epistemological sequence on evolution. The study showed that the students' attitudes did not change significantly.

Students coming from Islamic and Christian backgrounds, in a study by Dagher and BouJaoude (1997), showed similar results to those discussed previously. "The data show a strong connection between students' position regarding the theory and their religious affiliation" (Dagher & BouJaoude, 1997, p. 436). They also indicated that students who do have a good understanding of evolution still may not accept the theory. Putting these results together, the researchers concluded that students'

“combined beliefs about religion and about science strongly influence how students evaluate evidence for evolutionary theory by delimiting what counts as evidence and eventually interfering with understanding the theory” (Dagher & BouJaoude, 1997, p. 440). We also see this in the research regarding teachers and the disconnect between what they believe about religion and evolution teaching (Helms, 1998; Ost, 1995).

In a research project using Australian Lutheran students, Fysh and Lucas (1998) found that students did have opinions regarding the material they were taught in class and their religious beliefs. The study found that “in general, students were much more likely to see conflict between the Bible and evolution theory than were their teachers or clergy” (Fysh & Lucas, 1998, p. 63). They also found that students have a “lack of support...for the idea...that science is the sole arbiter of truth and reality” and that students believe that “...the supernatural is beyond scientific proof” (Fysh & Lucas, 1998, p. 63). These ideas show that Lutheran students are not much different from other students from varied backgrounds as seen in the preceding paragraphs and Aikenhead’s (1997) work.

2.12 Lutherans and Evolution Education

Significant to this study is the history of Lutherans who have been noteworthy in the history of evolution education. Bergman (1993) lists six Lutherans within the ranks of the prominent twentieth-century creationist movement scholars, including Byron Nelson, Theodore Graebner, Alfred Rehwinkel, Theodore Handrich, John Kolz, and Paul Zimmerman. This is significant to this study since Lutherans seem to be only second in numbers to Seventh-Day Adventists in numbers of people involved in the early years of the debate. Since this study is looking at Lutheran biology teachers and students in Lutheran schools, it is important to know that this particular Christian denomination has been at the cutting edge of the discussion on evolution education.

The Lutheran church is divided into three main church synods within the United States: the Lutheran Church Missouri Synod (LCMS), the Wisconsin Evangelical Lutheran Synod (WELS), and the Evangelical Lutheran Church in America (ELCA). In addition to these, there are some independent Lutheran churches as well. Each of

these churches finds its roots in the Book of Concord (1530), which is based on the teachings and writings of Dr. Martin Luther. During their immigration to America, Lutheran groups from the northern European nations formed the original American synods and often named themselves based on their geographic location.

Although it is the second largest of the three synods, the LCMS operates the most high schools of any of the three main groups, with 92 in the 2002-2003 school year (*Lutheran school statistics 2002-2003*, 2003), followed by WELS with 23 high schools (*WELS high schools*, 2004), and the ELCA with 20 high schools in the United States and Caribbean (*ELCA schools*, 2004). The LCMS also operates schools outside the United States and holds affiliations with Lutheran church bodies on every populated continent. The reach of the Lutheran church is world wide and dedication to education within the church continues to grow.

Historically, the LCMS has been a strong supporter of education. In some areas, the congregation of Lutherans would build the building for a school before creating a space in which to worship. The original 1847 constitution of the LCMS included language which would require a church to be operating a school before acceptance into the synod (Lutheran Church Missouri Synod, 1922). It is from this background that the LCMS has worked through the various educational reforms and proceedings of the past 157 years.

The Lutheran Church Missouri Synod does not have a specific doctrinal statement on evolution and the way it is taught in schools. In regard to doctrinal issues, the national church policy review committee, known as the Commission on Theology and Church Relations, will usually study and form a report which defines the official synodical position on an issue. This position statement would then be released to all the members of the synod. The members would analyse the statement and it would then be sent to the national convention for a vote of approval. This is how an official policy statement on the teaching of evolution would come about in the church if it were to happen.

There have been non-doctrinal statements created in the LCMS which work to explain the position of LCMS members. The first statement was from a series of pamphlets from the President of the Synod's office (A. L. Barry, 2000). This

pamphlet was “to provide a starting point from which to evaluate the claims made by advocates of evolution” (A. L. Barry, 2000, p. 2). It discussed in relatively simple terms the ideas of evolution, intelligent design, and the compatibility of evolution with the Bible. In not giving any complex answers, the pamphlet does initiate the ideas that there is a greater need for the study of science and the study of scripture to find Truth and that “Christians have no need to fear the findings of science, nor do they have any reason to give ‘science’ more credence than they give the Word of God” (A. L. Barry, 2000, p. 4).

The most recent statement on the teaching of evolution in Lutheran Schools comes from the recent Synod Convention in July, 2004. Control in the LCMS lies with the individual congregations which elect national organizational leadership and create unified policy through these national conventions. An amended floor resolution submitted by a congregation resolved that synodical schools “teach creation from the Biblical perspective... [and don’t] condone any teaching that contradicts...creation...as an explanation for the origin of the universe...[and] affirm the scriptural revelation that God has created all species” (“Resolution to commend preaching and teaching creation,” 2004, p. 1). This resolution was passed and therefore should be adhered to in the schools. It should be noted that this resolution is already being disputed and is not an absolute doctrinal statement. Processes to dialogue, form, and shape the policy continue.

The statements within the LCMS do not prohibit the teaching of evolution in Lutheran schools. As was discussed earlier, the purpose of teaching evolution can be for students to understand the scientific theory rather than believing it in its entirety. This would be akin to other classes in world religions where students hear about the belief systems of Buddhists or Hindus for knowledge rather than for proselytizing. It is with this understanding that evolution education can happen in a Lutheran school.

2.13 Test of Science Related Attitudes

Research is growing in the field of assessing attitudes of students toward subject matter. The Test of Science Related Attitudes (TOSRA) (Fraser, 1981) has been used in studies to research student opinions on seven subscales of science related attitudes (Brown, 1996; Goh, Young, & Fraser, 1995; Lott, 2002; Robinson, 2003; Smist, 1994;

White & Richardson, 1993). These subscales include social implications of science, normality of scientists, attitude to scientific inquiry, adoption of scientific attitudes, enjoyment of science lessons, leisure interest in science and career interest in science. This set of subscales was created based on Klopfer's (1971) research in science attitudes.

The TOSRA originated in Australia and was tested for validity in schools there and in the United States (Fraser, 1981). Validity was reconfirmed for use of the TOSRA with American students in 1994 in a study by Smist. This research was based on a nationwide survey of 572 high school students in biology and chemistry courses. She found that

... the strength of TOSRA is that it is multidimensional, that we can look at specific areas under the broad heading "attitudes toward science", referring to the ability of the subscales to pinpoint which aspects of science are high and low. (Smist, 1994, p. 7)

The use of the TOSRA for this study will add to the testing of its validity as well as increasing the understanding of student attitudes toward science. Validation of the TOSRA for this study will be discussed in Chapter 3.

Two previous studies (Brown, 1996; Lott, 2002) used the TOSRA to gain pre-test/post-test comparison data analysis of student attitudes. Lott (2002) used the TOSRA to compare students' science attitudes as a result of their participation in the Alabama Science in Motion in-service and outreach program. It was found that students' science attitudes did not significantly change between the pre-test and post-test administrations of the TOSRA. Brown implemented the pre-test/post-test use of the TOSRA on college students at the beginning and end of a semester-long environmental science course (1996). This was to determine if there was a change in student science attitudes after exposure to the inquiry-oriented course. Significant positive change was determined in two of the seven scales (Brown, 1996). This method of analysis is used in the current study since this instrument can be used as a tool for analysing significant change in attitude for a large number of participants in a reasonable amount of time.

2.14 Teaching Evolutionary Topics Survey

Research in the field of assessing teachers' emphasis on evolutionary topics has been growing since the late 1980's. The Teaching Evolution Topics Survey (TETS) (Bilica, 2001) was created to investigate the emphasis teachers placed on evolution, the factors influencing that decision, and the demographics of the participants. This survey was created using the concepts found in the *National Science Education Standards* (National Research Council, 1996) and *Project 2061* (American Association for the Advancement of Science, 1990, 1993) as well as through expert review. The validation of the instrument is explained in Chapter 3.

The TETS has four sections for teachers to complete. The first section describes the teacher's *Emphasis on Evolution*. This section of 28 items is grouped according to the seven fundamental concepts of evolution as derived from the resources explained above. The second section of the TETS is called *Factors Influencing Your Decision*. This section reports a teacher's feeling about what causes him to teach or not teach about evolution. This section was grouped into eight dimensions of influence, including Personal Teaching Capacity, Student Learning, Evolution and Science, Evolution and Teaching, Evolution and School, Parents and Evolution, Textbook and Evolution, and finally Time and Resources. The third section obtained demographic information from the participants. Some of the included demographics were age, experience, location and training. The final section of the survey is a free-response comments section. This final part of the survey was voluntary on the part of the participant.

The original TETS survey was used in a study by Bilica to assess school teachers in Texas. The survey used here was modified to address the change in the study population from those mainly public school biology teachers in Texas to Lutheran parochial school biology teachers across the United States. All the modifications were in the demographics section of the test. This survey was used to continue gaining comparable data with previous studies by Bilica (2001), Bilica and Skoog (2002) and others (Aguillard, 1999; Cherif et al., 2001; Ellis, 1986; Osif, 1997; Rutledge & Mitchell, 2002; Rutledge & Warden, 2000; Shankar & Skoog, 1993; Skoog & Bilica, 2002; Tatina, 1989; Van Koevering & Stiehl, 1989; Weld & McNew, 1999; White & Richardson, 1993; Zimmerman, 1987).

2.15 Summary

This chapter has reviewed the history of evolution education in the United States, the research studies regarding teacher and student attitudes toward evolution education, the Lutheran church and its involvement with evolution education, and the instruments being used to measure teacher and student attitudes.

This project has a number of outcomes. It aims to find comparisons between teachers in public and private institutions and how they approach evolution education. This includes how much of the topic of evolution they teach as well as the factors and influences on their choices for teaching evolution. The study will also determine if students' attitudes toward science change as result of participating in a unit on science education. The results will increase the knowledge of the science education community.

This study is ground breaking for three reasons. First, no national study has been done on biology teacher attitudes toward science. Previous studies included teachers within the geographic region of a single state (Aguillard, 1999; Cherif et al., 2001; Ellis, 1986; Osif, 1997; Rutledge & Mitchell, 2002; Rutledge & Warden, 2000; Shankar & Skoog, 1993; Skoog & Bilica, 2002; Tatina, 1989; Van Koevering & Stiehl, 1989; Weld & McNew, 1999; White & Richardson, 1993; Zimmerman, 1987). Second, this study concentrates on Lutheran High School teachers and students rather than public school teachers. No study has been found using this American population for research on science attitudes. Finally, this study will show the degree to which evolution is taught in Lutheran high schools. This will eliminate the need for anecdotal evidence and hearsay about the subject in Lutheran high schools.

The methodology for this study is outlined in Chapter 3.

CHAPTER 3

Methodology

3.1 Introduction

The purpose of this study is to explore the conditions and effects of evolutionary education in parochial schools. To do this, quantitative survey methods were employed to gain information on the following questions: To what degree do Lutheran secondary school biology teachers incorporate evolution in their teaching of basic first year biology courses?; What is the amount of emphasis given by Lutheran biology teachers to the seven fundamental concepts of evolution?; How do Lutheran biology teachers compare in their emphasis of evolution education to their public counterparts across the United States?; and Does exposure to evolution education change attitudes toward science of Lutheran high school biology students?

The previous chapter presented a literature review which pointed out the various aspects of the way evolution education has developed in the last century and specifically how court cases, scholars, and teachers have developed and changed the face of evolution education in America and throughout the world. In this chapter, the methodology for comparing pedagogy of the private schools with public schools and the measurement of student attitudes will be explained.

3.2 Research Design

This study was primarily quantitative using two survey questionnaires. Surveys were chosen since the “distribution of variables...[are] difficult to observe...[and] the population under consideration is relatively large” (Crowl, 1996, p. 235). Observing hundreds of classrooms for periods of between one and three weeks would not be reasonable. This design also fits as Fraser and Walberg (1981) describe the benefits as being feasible in terms of cost and time. As Fraser also points out:

the approach described here, which defines classroom or school environment in terms of the shared perceptions of the students and teachers in that environment, has the dual advantage of characterizing the setting through the eyes of the actual

participants and capturing data that the observer could miss or consider unimportant. (1994, p. 494)

Another factor in choosing the survey design is to broaden and extend the study by Bilica (2001), which researched emphasis given by teachers to evolution education in Texas schools. This study also continues a line of research in various states (Aguillard, 1999; Ellis, 1986; Osif, 1997; Rutledge & Warden, 2000; Shankar & Skoog, 1993; Tatina, 1989; Van Koevering & Stiehl, 1989; Weld & McNew, 1999; Zimmerman, 1987) looking at the science attitudes and time given to evolution education. Although this study will be a national study rather than a state study, as well as examining private schools rather than public, it will broaden the whole of knowledge about evolution education.

3.3 Instruments

3.3.1 Teacher Survey

To normalize this study, a survey instrument was chosen which delineates specific topics in evolution which are widely accepted. In Bilica's (2001) Teaching Evolution Topics Survey (TETS) instrument for assessing teacher emphasis on evolution topics, seven concepts were identified as being central to evolution (*Appendix A*). This was done by Bilica in choosing salient topics within the *National Science Education Standards* (National Research Council, 1996). Each of these topics can be found in other frameworks for science education including the *Scope, Sequence, and Coordination Project* (National Science Teachers Association, 1992), *Science for All Americans* (American Association for the Advancement of Science, 1990), and the *Statement on Teaching Evolution* (National Association of Biology Teachers, 2004).

The four part TETS survey was created to measure teachers' "emphasis on evolution and the factors that influence teachers' decisions about teaching evolution" (Bilica, 2001, p. 40). The instrument's content validity was established by experts in the fields of evolution education, science education and research methodology. The instrument's internal consistency was validated at a .77 to .96 level for part one in the pilot instrument and .58 to .93 for part two (Bilica & Skoog, 2002). Part three of the survey includes demographic information and was not tested for reliability. The fourth section to the survey included an optional comments section, which was also

not tested for reliability. The reliability range is acceptable for part one according to a scale produced by Vierra, Pollock, and Golez (1998). Analysis will only be done on individual questions from part two and scales whose reliability is at .70 or higher.

Part one of the TETS survey deals with the emphasis on evolution where teachers indicate how much emphasis they currently give to the seven general topics of evolution during the school year. It also determines how much emphasis they would give if they were to make the sole decision without outside influences of school boards, administrators, parents, and students. Teachers rank each topic on a Likert scale from 1 to 5. The Likert scale was divided by the following definitions:

1- No emphasis- I do not emphasize this concept at all.

2- Little emphasis- I may mention this briefly or informally during the course.

3- Some emphasis- I emphasize this concept in one lesson during the course.

4- Moderate emphasis- I emphasize this concept in more than one lesson during the course.

5- Strong emphasis- I emphasize this concept throughout the course.

The seven general topics of evolution education were formulated from a number of national statements on evolution education (American Association for the Advancement of Science, 1990; National Association of Biology Teachers, 2004; National Research Council, 1996; National Science Teachers Association, 1992). Bilica (2001) assembled these and created the following categories and their associated sub-topics:

1. Speciation scale:

Sub-topics

A. Defining species

B. Reproductive and geographic isolation

C. New species evolve from older species

2. Diversity scale:

Sub-topics

A. Diversity as a product of evolution

B. Classification systems

C. Adaptation

3. Descent with modification scale:

Sub-topics

A. Common ancestry between species

B. Phylogenetic diagrams (tree diagrams)

C. Single-celled ancestor to all living organisms

4. Evidence for evolution scale:

Sub-topics

A. Fossil evidence

B. Molecular evidence

C. Anatomic and behavioural evidence

5. Natural selection scale:

Sub-topics

A. Genetic variation

B. Environmental selection

C. Differential reproduction in genetic inheritance

6. Pace and rate of evolutionary change scale:

Sub-topics

A. Geologic time

B. Evolution does not progress in a set direction

C. Gradual versus rapid evolutionary changes

7. Human evolution scale:

Sub-topics

- A. Common ancestry of humans and other primates
- B. Early hominids
- C. Modern humans evolved recently

Part two of the survey deals with factors influencing the teacher's decisions regarding coverage of evolution topics. In this 25 question section, teachers respond to statements using Likert scale responses of strongly disagree, disagree, undecided, agree, and strongly agree. This section was grouped into the following eight different dimensions of influence on teaching:

1. Personal teaching capacity (PTC) (including academic preparation and knowledge)

Sample statements:

- I am academically well prepared to teach evolution.
- I am confident in my ability to teach evolution effectively.

2. Student learning (SL) (including students' interest and capacity to learn)

Sample statements:

- Evolution is too complex for beginning biology students.
- All students are capable of understanding evolution.

3. Evolution and science (EAS) (including teachers beliefs about evolution)

Sample statements:

- Evolutionary topics are supported by scientific evidence.
- Evolution is a central and unifying theme in biology.

4. Evolution and teaching (EAT) (including controversy associated with teaching evolution and avoiding topics)

Sample statements:

I sometimes substitute the words “change over time” for “evolution” to avoid conflicts.

I do not teach some concepts, such as human evolution, because they are too controversial.

5. School principal and evolution (SAE) (including support from their administrators)

Sample statements:

The principal at my school supports teaching about evolutionary topics.

My principal would ask me to de-emphasize evolution in my class if parents protested against it.

6. Parents and evolution (PAE) (including parental support for teaching)

Sample statements:

The parents at my school agree that students should learn about evolution.

I have felt pressure from parents in my community to avoid teaching some evolution concepts.

7. Textbook and evolution (TXT) (including reliance on textbooks for information)

Sample statements:

My textbook presents sufficient information about evolution.

To teach evolution effectively, I must supplement the information in my textbook.

8. Time and resources (TIM) (including substituting course material)

Sample statements:

In order to teach evolution comprehensively, I must eliminate other topics from my biology course

I would like to emphasize evolution more, but there is not enough time available to do so.

Part three of the survey deals with demographic information of the participants. The questions used in this study include information on teaching years of experience, gender, age, highest tertiary degree held, completed tertiary biology coursework, state certification, and community setting. These demographic variables were analysed for significance in comparison to the first two sections of the survey.

Part four of the survey is an optional comments section for free response. This section was left as an open venue for teachers to make any statements they deemed necessary. This section adds a bit of qualitative data to this mainly quantitative study. Answers in this section could help clarify results from the data analysis. Although optional, this section was used by 68.4% (52) of the teachers to explain answers or detail opinions about evolution. The answers will be discussed more in Chapter 5 of this study.

The TETS (Bilica, 2001) was modified for this study (*Appendix A*). The modifications included adding one question to the demographic information and changing three demographic questions to fit a national study area rather than the original Texas study area. The added question was to ask whether or not the respondent was trained in the Lutheran university system. The first demographic question changed was, "Are you certified to teach biology in Texas." It was changed to "Are you certified to teach biology in your state." The phrasing of the question "Which of the following best describes your location in Texas?" was changed to "Which of the following best describes your location?" The responses were changed to North Eastern United States, South Eastern United States, Midwest, North Western United States, and South Western United States, from locations in Texas. The final question change described school enrolment. Since the average size of Lutheran high schools in the Lutheran Church Missouri Synod, which holds over 90% of the United States Lutheran high schools on its roster, is 212 students (*Lutheran School Statistics 2002-2003*), the school size range was modified to reflect the smaller school populations.

This survey was mailed to 100% of the Lutheran high school biology teachers (N=128) in the United States. School addresses and teacher names were compiled from the Valparaiso Lutheran High School database (Karpenko, 2004) and the Lutheran Annual (*The lutheran annual*, 2003). This sample size represents the entirety of Lutheran high school teachers in the United States. These schools are affiliated with the Lutheran Church Missouri Synod (LCMS), the Evangelical Lutheran Church in America (ELCA), the Wisconsin Evangelical Lutheran Synod (WELS) and other independent Lutheran churches. The mailing included a copy of the modified TETS survey, a cover sheet explaining the survey and directions (*Appendix B*), and a return addressed stamped envelope for returning the survey instrument.

The surveys were sent the first week of October 2003 and were personally addressed to each biology teacher, where a name was furnished by the directory of Lutheran High Schools (Karpenko, 2004) or on the homepage of the school or through contacting the school office by phone. The target return date was October 31, 2003. Each teacher had been made aware of the survey's coming arrival through either a phone message or email message from the researcher within two weeks of receipt of the survey. A follow-up post card (*Appendix C*) was mailed to each teacher three weeks after the initial mailing of the surveys. There was no incentive offered for completion and return of the surveys.

The expected return rate of the teacher surveys was between 30% and 48% based on the distribution of related surveys by Bilica (2001) and Shankar and Skoog (1993). This fits with Kirk's (1995) assessment that typically between 10% and 45% of mailed surveys will be returned.

A total of 81 surveys were returned by March 1, 2004. Two surveys were returned by the U.S. Postal service as undeliverable bringing the total of respondents to 79. Of these 79 surveys, three were either filled out incorrectly or returned only with the comments section filled out. These were also eliminated from the usable surveys bringing the number to 76. By dividing the usable surveys (76) by the net surveys delivered (126) the return rate was determined to be at 60.3%.

Compared to the 2001 study by Bilica and the 1993 study by Shankar and Skoog, a return rate of 60.3% would be considered above average. Several factors may have

contributed to this high response rate. First, making an initial contact by phone, to alert teachers to the arrival of the survey packet, allowed teachers to identify the packet as something other than the junk mail with which they are bombarded daily. Second, to further alert teachers to the importance of the letter, surveys were addressed to specific recipients rather than a non-descript title of "Biology Teacher." Multiple letters were sent to schools where more than one biology teacher was present. Finally, the surveys were anonymous which would ease fears of retribution from administration, school boards, and church officials who may disagree with teacher opinions. Each of these things may have had a positive effect on the return rate.

3.3.2 Student Survey

The Test of Science Related Attitudes (TOSRA) was proctored following the directions in the TOSRA handbook (Fraser, 1981). This test of seven subscales: social implications of science; normality of scientists; attitude to scientific inquiry; adoption of scientific attitudes; enjoyment of science lessons; leisure interest in science; and career interest in science; was used to determine whether exposure to a unit on evolution education would change the attitudes of students toward science.

Validity of the TOSRA was found by Smist (1994) in American schools. This corroborated earlier data when the TOSRA was originally tested for validity in Australia and the United States (Fraser, 1981). Smist's research was based on a nationwide study of 572 high school students in biology and chemistry courses. She found that "the strength of TOSRA is that it is multidimensional, that we can look at specific areas under the broad heading 'attitudes toward science'", referring to the ability of the subscales to pinpoint which aspects of science attitudes are high and low (Smist, 1994, p. 7). This will be useful in this survey to infer if any subscale average changes significantly after the teaching intervention.

The TOSRA is a 70 item questionnaire which follows the Likert (1932) scale format (*Appendix D*). Each item on the survey has responses rated on a five-point scale to show agreement or disagreement with the statement presented. These responses as shown on the TOSRA are Strongly Agree (SA), Agree (A), Not Sure (NS), Disagree (D), Strongly Disagree (SD). Each item is given a score between 1 and 5. Some questions are worded negatively to negate the possible effect that students will try to

fake their responses. Fraser (1981) also indicates that if the TOSRA will not have an effect on the academic standing on the student, the possibility of students faking answers will be diminished.

The schools were chosen based on location, administrative approval, teacher approval, and the annual teaching of a unit on evolution. The schools studied are within the geographic region of the Pacific Southwest District of the Lutheran Church Missouri Synod. This covers the land area of southern California, southern Nevada, and Arizona. This representative sample of Lutheran Schools is typical throughout the states with some of the schools serving fewer than 100 students to schools which are at above average size. They are also typical in that the students come from a diversity of economic backgrounds while ethnically a majority of students in the schools are Caucasian. Each Lutheran school biology teacher in that area was phoned or emailed asking if evolution was taught as a unit in the basic biology class at the school and if they would be willing to allow research to be done at their school. This process eliminated 7 of the 14 schools. The principal or a head administrator of the final 7 schools were emailed a letter asking for permission to use their school as a test site (*Appendix E*). Each of the seven school heads gave their consent by phone or email. Once this process was finished, each biology teacher was contacted to arrange for scheduling of the pre-test and post-test. All the surveys were completed between November 2003 and April 2004, which correlated with the scattered dates when the supervising teachers conducted the evolution unit in their biology classes.

Each biology teacher was mailed a copy of the student consent form to be distributed to the students (*Appendix F*). This form was then given to the students between two and five days before the pre-test was administered. Students were to bring the form back to school signed by parents to signify non-consent to participate in the study. The completed forms were given to the researcher on the day of the survey. Non-participant students were dismissed from the room.

The original research group consisted of $n = 660$ biology students at seven Lutheran high schools in Arizona, California, and Nevada. The 11 students who refused the opportunity to participate or were excluded by their guardians were not counted in this study group. One hundred eighty one (181) students were eliminated from the pre-test/post-test correlations due to incompleteness of either the pre-test or the post-

test. Students may have missed one of the assessment dates due to health, extracurricular activities, or school dismissal. This brought the size of the student research group to $n = 479$ for the analysis of attitudes.

3.4 Data Entry

Once the TETS were returned in the prepaid envelope, the data were entered into Microsoft Excel XP spreadsheets. Each numbered question on the survey was entered as a field in separate columns in the sheet. Names of teachers were not required nor recorded on the survey answer sheets and were not included in the database information. These data were analysed using SPSS version 12.

The TOSRA results were similarly entered into Microsoft Excel XP spreadsheets. Each student response paper was given a number on the pre-test and subsequently matched to the post-test survey response sheet. These data were entered into the spreadsheet so as to match pre-test and post-test results. These data were analysed using SPSS version 12.

3.5 Data Analysis

The TOSRA data were analysed using SPSS version 12. This analysis determined the internal reliability and validity of the seven scales of science attitudes. The Cronbach (1951) alpha coefficient was used to measure reliability while ANOVA was used to check the validity of the test. The Pearson r was used to find correlation between the seven scales of science attitudes.

The TOSRA responses were also used to determine a change in attitudes of students after students had been exposed to a unit on evolution. This was done using the paired samples t -test to check for significant difference between the pre-test and the post-test scores. This type of comparison has been used in other quasi-experimental studies looking at changes in attitudes after an intervention (Eryilmaz, 2004; Kristjánsson, Helgason, Månsson-Brahme, Widlund-Ivarson, & Ullén, 2003; Olson, 2002).

The TETS data were analysed using SPSS version 12. This analysis checked the responses for internal reliability and validity on the seven evolution concepts of speciation, diversity, descent with modification, evidence for evolution, natural selection, pace and rate, and human evolution using the Cronbach (1951) alpha coefficient reliability. Descriptive statistics, ANOVA, and paired sample t -test

measures were also used on the TETS data to determine relationships between demographic variables and responses to the survey.

The TETS data from the comments section were analysed for common commentary themes. This qualitative data were compared to the quantitative data to further derive meaning from the responses.

3.6 Data Analysis and Research Objectives

This section summarizes the specific ways the data analysis links to the research objectives.

Objective 1- Is the TOSRA a valid and reliable instrument for testing science attitudes of parochial school students in the United States?

Research strategies

-Administer the TOSRA to parochial school students in Lutheran secondary schools in the pacific southwest United States. Quantitative data were collected from 479 students and analysed for internal consistency and validity using SPSS version 12.

Objective 2- Does exposure to evolution education change the science attitudes of Lutheran high school biology students?

Research strategies

-Administer the TOSRA to parochial school students in Lutheran secondary schools in the pacific southwest United States in a pre-test / post-test circumstance with an evolution unit being taught as the intervention. Analyse the data for significant changes in science attitudes between the two administrations.

Objective 3- To what degree do Lutheran secondary school teachers incorporate evolution in their teaching of basic first year biology courses?

Research strategies

-Administer the TETS survey to all biology teachers teaching at Lutheran high schools in the United States. Using descriptive statistical analysis, quantitative data were collected on current teaching emphasis with regard to time spent in the classroom on the seven fundamental evolutionary topics.

Objective 4- What is the amount of emphasis given by Lutheran biology teachers to the seven fundamental concepts of evolution as compared to the amount of emphasis they would place on each concept given unlimited freedom to decide the curriculum?

Research strategies

Administer the TETS survey to all biology teachers teaching at Lutheran high schools in the United States. Paired sample t-tests were used to analyse quantitative data collected on current teaching emphasis and preferred teaching emphasis in regard to time spent in the classroom on the seven fundamental evolutionary topics.

Objective 5- How do Lutheran biology teachers compare to public school teachers in their emphasis of evolution education in their classroom and the influences which guide their decisions?

Research strategies

Literature was reviewed and examined with relation to teacher emphasis on evolution and factors influencing those decisions. Quantitative and qualitative data were collected from Lutheran biology teachers regarding emphasis on the seven fundamental concepts of evolution and factors influencing those decisions using the TETS survey. These data were compared with data from previous studies.

Objective 6- Do demographic characteristics of gender, years of teaching experience, age, highest tertiary degree held, completed tertiary biology coursework, location of tertiary work, state certification, or community setting influence Lutheran teacher emphasis on evolution?

Research strategies

Quantitative data were collected from Lutheran biology teachers regarding, demographics, emphasis on the seven fundamental concepts of evolution, and factors influencing those decisions using the TETS survey. This data were analysed using ANOVA and paired sample t-tests for significance.

3.7 Summary

In summary, the TETS and the TOSRA were used in this study since they give a good overview of teacher and student attitudes toward evolution education. The reliability and validity of each of these instruments has been shown in previous studies although they were again analysed in this study. The TETS instrument was modified to reflect a larger geographic population than its original Texas application. The study cohort consisted of Lutheran high school biology teachers and Lutheran high school biology students. The teacher cohort was based on a 60% rate of return and accounted for over half of all Lutheran high school biology teachers in the United States. The student cohort represented the opinions of Lutheran high school biology students in the pacific southwest area of the United States. Once all the data were collected and entered into spreadsheets, they were analysed using SPSS 12. The results and conclusions obtained by that analysis are examined in Chapter 4 and Chapter 5.

CHAPTER 4

Results

4.1 Introduction

The previous chapter described the methodology for investigating the research questions. The research design and instruments used were discussed including the reliability of the instruments as demonstrated from previous studies. Research subject selection and rates of return for mailed surveys were also examined.

This chapter presents the results regarding reliability and validity of the TOSRA survey given to Lutheran high school students and t-Test results regarding change in student science attitudes. This chapter also reports statistical analysis of teacher responses to the TETS survey and significant findings between demographics of the respondents and their responses to the survey.

4.2 Validation of the TOSRA

This section presents the results of the analyses calculated from student responses to the TOSRA. The data were taken by surveying the pool of students ($n = 660$) in pre-test and post-test conditions with a single intervention of a one to four week unit on evolution. Out of the original pool of students from seven Lutheran high schools in the pacific southwest of the United States, 181 were eliminated due to lack of completion of either the pre-test or the post-test. The total number of usable student surveys was 479. These surveys were used to provide further validation of the reliability of the TOSRA and to show the effects of evolutionary lessons on the science related attitudes of biology students in Lutheran high schools.

Table 4.1 presents the internal consistency reliability of the scales of the TOSRA and the discriminate validity for these scales. In keeping with previous studies with regard to use of the TOSRA, Cronbach's alpha reliability coefficient of internal consistency (1951) is used to report reliability. In this study, the TOSRA is shown to have a high degree of internal consistency with values ranging from 0.70 to 0.93 for the seven scales. This range is acceptable according to Nunnally (1978) who recommends levels of 0.60 or greater for scales like these. The discriminate validity

is used to determine if scales in an instrument are measuring differing concepts. This is done by analysing the mean correlation of one scale with the other scales. The discriminate validity found here ranged between 0.31 and 0.56 and is appropriate for an attitudinal survey of this type, although the Enjoyment of Science, Leisure Interest in Science and Career Interest in Science scales are more highly correlated and similar to each other. These values provide continued support of the reliability and validity of this instrument with American students.

Table 4.1

Internal Consistency Reliability (Cronbach Alpha Coefficient) and Discriminant Validity (Mean Correlation Values) for the TOSRA Scales

Scale	Alpha Reliability	Discriminate Validity
Social	0.82	0.46
Normality	0.70	0.31
Inquiry	0.84	0.32
Adoption	0.72	0.48
Enjoyment	0.93	0.56
Leisure	0.89	0.52
Career	0.90	0.56

n = 479

4.3 Validation of the TETS

Section one of the TETS survey was constructed to determine the emphasis given by teachers to the seven fundamental topics of evolution (Bilica, 2001). Teachers responded on a five point Likert scale for current teaching emphasis of the topics and for preferred emphasis given unlimited freedom to choose what is taught and how much time given to the subject matter.

Table 4.2 describes the alpha reliabilities and discriminate validity for the teacher emphasis scales. Cronbach alpha coefficients were found to be between 0.67 and 0.97 for the seven teacher emphasis scales. These are considered appropriate for a survey such as this and are consistent with the range of alpha coefficient values (0.81 to 0.97) found by Bilica (2001).

Table 4.2

Internal Consistency Reliability (Cronbach Alpha Coefficient) and Discriminant Validity (Mean Correlation Values) for the Teacher Emphasis Scales

Scale	Alpha Reliability	Discriminate Validity
Speciation	0.67	0.56
Diversity	0.88	0.61
Descent with modification	0.95	0.65
Evidence for Evolution	0.97	0.69
Natural Selection	0.95	0.57
Pace and Rate of Change	0.95	0.66
Human Evolution	0.96	0.63

n = 76

4.4 Analysis of the TOSRA

Table 4.3 presents the mean, standard deviation, and *t*-value for the pre-test and post-test comparison of the TOSRA. Significant changes in student science attitudes were found as indicated on the Normality of Scientists and Attitude Toward Inquiry scales ($p < 0.01$) and the Adoption of Scientific Attitudes and Leisure Interest in Science scales ($p < 0.05$). The attitudes toward the normality of scientists and the leisure interest in science increased while the attitudes toward inquiry in science and adoption of science attitudes decreased.

Table 4.3

Mean, Standard Deviation, Mean Difference, and t-Value for Pre-test and Post-test TOSRA Scales

Scale Item	Pre-test mean	Pre-test std. dev.	Post-test mean	Post-test std. dev.	Mean difference	<i>t</i>
Social	3.57	0.50	3.54	0.50	-0.03	1.89
Normality	3.38	0.39	3.42	0.48	0.05	2.93**
Inquiry	3.49	0.64	3.42	0.70	-0.07	3.01**
Adoption	3.46	0.48	3.42	0.50	-0.04	2.08*
Enjoyment	2.85	0.85	2.85	0.85	0.01	0.06
Leisure	2.29	0.76	2.34	0.78	0.05	2.34*
Career	2.68	0.77	2.71	0.77	0.03	1.19

n = 479 * $p < 0.05$ ** $p < 0.01$ (2-tailed)

4.5 Analysis of the TETS

This section presents the results of the statistics calculated from teacher responses to the modified TETS survey instrument. These data were taken from usable mailed surveys, from a pool of all Lutheran high school biology teachers in the United States ($n = 76$). This represents a 60.3% return rate, which is considered above average for a mailed return survey as compared to similar studies by Bilica (2001) and Shankar and Skoog (1993). These surveys were used to show descriptive statistics about the amount of time teachers spend on evolutionary topics, calculating significant variances between demographic subgroups of teachers and teacher comments regarding the survey.

4.5.1 TETS Section 1 - Degree of Teaching Emphasis Scales

The raw teaching emphasis data of the seven fundamental concepts of evolution showed that all teachers teach some concepts of evolution in their classrooms. This is a higher percentage than previous studies by Zimmerman (1987) in Ohio with 88% in teaching about evolution and Ellis (1986) with 91% teaching evolution in Kentucky. It is also higher than that found in South Dakota by Tatina (1989) at 73%, but the definition of teaching about evolution in that study focused on larger time periods spent teaching about evolution.

Table 4.4 presents the frequency response for the teachers' current emphasis on evolution while Table 4.5 presents their preferred emphasis. Teachers reported their emphasis based on a five point Likert scale. A rating of 1 would indicate "no emphasis" while a 5 would indicate "strong emphasis." The survey instrument included further instruction for the respondents of the scale points meaning (*Appendix A*).

It was found that teachers place varying amounts of emphasis on the seven fundamental concepts of evolution. Seventy-five percent of Lutheran teachers speak about speciation in one lesson or more while 84.2% of them speak about the concept of diversity and 81.6% natural selection. Evidence for evolution is emphasized in one lesson or more by 59.2% of teachers and the pace and rate of evolution is emphasized by 51.2%. Descent with modification at 44.7% and human evolution at 30.2% are the least emphasized concepts in one lesson or more for teachers. These

findings are similar to the findings by Aguillard (1999) and Bilica (2001) for the amount of emphasis on evolutionary topics.

Table 4.4

Frequency by Percentage of Teachers' Reported Current Emphasis on the Seven Fundamental Concepts of Evolution Mean Values

Fundamental concept	No Emphasis	Little Emphasis	Some Emphasis	Moderate Emphasis	Strong Emphasis
Speciation	6.6	18.4	38.2	32.9	3.9
Diversity	2.6	13.2	25.0	32.9	26.3
Descent with Modification	25.0	30.3	30.3	10.5	3.9
Evidence for Evolution	11.8	28.9	32.9	17.1	9.2
Natural Selection	6.6	11.8	30.3	39.5	11.8
Pace and Rate	25.0	23.7	28.9	19.7	2.6
Human Evolution	50.0	19.7	11.8	17.1	1.3

n = 76

Table 4.5

Frequency by Percentage of Teachers' Reported Preferred Emphasis on the Seven Fundamental Concepts of Evolution Mean Values

Fundamental concept	No Emphasis	Little Emphasis	Some Emphasis	Moderate Emphasis	Strong Emphasis
Speciation	6.6	14.5	36.8	36.8	5.3
Diversity	2.6	10.5	25.0	31.6	30.3
Descent with Modification	21.1	31.6	28.9	14.5	3.9
Evidence for Evolution	10.5	26.3	31.6	18.4	13.2
Natural Selection	5.3	11.8	25.0	39.5	18.4
Pace and Rate	22.4	19.7	34.2	19.7	3.9
Human Evolution	39.5	18.4	19.7	18.4	3.9

n = 76

Table 4.6 presents the ranked mean and standard deviation for the current and preferred emphasis on the seven fundamental concepts of evolution. The rankings nearly mimic the findings by Bilica (2001) with pace and rate ranking lower than descent with modification. Shankar and Skoog (1993) also found that the concept of human evolution was nearly ignored in the teaching of evolution. In paired sample *t*-tests each fundamental concept scale showed significant difference to the others except for the Diversity and Natural Selection mean scales which did not show significant difference ($t = 1.12$).

Table 4.6

Ranked Mean and Standard Deviation for Current and Preferred Emphasis of the Seven Fundamental Evolution Concepts

Scale Item	Current scale mean	Current std. dev.	Preferred scale mean	Preferred std. dev.
Diversity	3.38	0.80	3.48	0.78
Natural Selection	3.24	0.95	3.40	0.96
Speciation	2.91	0.84	3.00	0.87
Evidence for Evolution	2.71	1.09	2.89	1.15
Pace and Rate	2.36	1.01	2.54	1.05
Descent with Modification	2.18	0.98	2.31	1.02
Human Evolution	1.84	1.03	2.14	1.15

n = 76

Table 4.7 describes the scale mean, standard deviation, *t*-value, and mean difference for the current and preferred emphasis on the fundamental concepts of evolution. A significant difference was found as indicated on the Speciation scale ($p < 0.05$) and the Diversity, Descent with Modification, Evidence for Evolution, Natural Selection, Pace and Rate, and Human Evolution scales ($p < 0.01$). This is in agreement with Bilica (2001) who also found significant differences between current and preferred scales of teaching emphasis in the seven fundamental concepts of evolution.

Table 4.7

Scale Mean, Standard Deviation, Mean Difference, and t-Value for Current and Preferred Emphasis on Evolution Concepts

Scale Item	Current scale mean	Current std. dev.	Preferred scale mean	Preferred std. dev.	Mean difference	t
Speciation	2.91	0.84	3.00	0.87	-0.09	2.33*
Diversity	3.38	0.80	3.48	0.78	-0.10	2.86**
Descent with Modification	2.18	0.98	2.31	1.02	-0.13	3.25**
Evidence for Evolution	2.71	1.09	2.89	1.15	-0.18	2.91**
Natural Selection	3.24	0.95	3.40	0.96	-0.16	3.71**
Pace and Rate	2.36	1.01	2.54	1.05	-0.18	3.59**
Human Evolution	1.84	1.03	2.14	1.15	-0.30	4.02**

n = 76 * $p < 0.05$ ** $p < 0.01$ (2-tailed)

ANOVA analysis was done to determine if there were significant differences between the current and preferred emphasis on evolution and the demographic factors of age, years of teaching experience, gender, highest tertiary degree held, amount of tertiary coursework in biology, state certification, and community setting. Significance was only found between highest tertiary degree held and the two fundamental concepts of human evolution and evidence for evolution. Shankar and Skoog (1993) and Aguillard (1999) also found a relationship with teacher educational background and their emphasis on evolution. The Post hoc Tukey test revealed significant variance in both cases to be between holders of bachelor degrees plus hours and those having master degrees plus hours. Teachers holding the master degree plus hours had a higher scale mean and placed significantly more emphasis on the human evolution and evidence for evolution scales. Table 4.8 describes the scale mean, standard deviation, and f-value for these concepts.

Table 4.8
Mean and Standard Deviation for ANOVA Comparison of Highest Degree Demographic Differences to the Seven Fundamental Concepts of Evolution.

Fundamental concept	n	Scale Mean	Std. Dev.	F Value
Speciation	76	3.03	1.05	1.35
Diversity	76	3.43	0.77	0.87
Descent with Modification	76	2.25	0.98	1.14
Evidence for Evolution	76	2.80	1.08	4.22*
Natural Selection	76	3.32	0.93	1.36
Pace and Rate	76	2.45	1.01	1.99
Human Evolution	76	1.99	1.04	4.63*

*p<0.05

4.5.2 TETS Section 2 - Teaching Influence Dimension Scales

Teachers were asked in part two of the TETS survey to respond to statements regarding influences on their teaching emphasis. They responded using a five point Likert scale where a score of 1 represented “strongly disagree” while a score of 5 represented “strongly agree.” The following frequency tables (4.9-16) describe teacher responses to the eight teaching influence dimension scale questions.

Table 4.9 presents the frequency in percentages of teacher responses to the questions in the Personal Teaching Capacity (PTC) scale. A strong majority (72.3%) of the teachers felt they were academically well prepared to teach evolution, which was higher than those who felt confident in their ability to teach evolution effectively (61.9%). A majority (73.7%), however, would not emphasize evolution more if they had a knowledge of it.

Table 4.9

Frequency by Percentage of Teacher Responses Reported on the Personal Teaching Capacity Dimension

Statement	Strongly Disagree	Disagree	Undecided or Don't Know	Agree	Strongly Agree
I am academically well prepared to teach evolution	3.9	14.5	9.2	52.6	19.7
I am confident in my ability to teach evolution effectively	3.9	18.4	14.5	46.1	15.8
I would like to emphasize evolution more if I had a knowledge of it	25.0	48.7	13.2	13.2	0.00

n = 76

Table 4.10 presents the frequency in percentages of teacher responses to the questions in the Student Learning (SL) scale. A majority of teachers (79.0%) disagreed that “Evolution is too complex for beginning biology students” which fits with the smaller majority response (65.8%) that agreed with the statement “All students are capable of understanding evolution.” Although these percentages are close to Bilica’s (2001) findings of 67% of teachers agreeing, this is highly different from Aguillard (1999) where only 30% of teachers agreed that all students are capable of understanding evolution. Just over half the teachers (52.6%) agreed that their students are interested in learning about evolution while 19.7% didn’t know or were undecided.

Table 4.10

Frequency by Percentage of Teacher Responses Reported on the Student Learning Dimension

Statement	Strongly Disagree	Disagree	Undecided or Don't Know	Agree	Strongly Agree
Evolution is too complex for beginning biology students	23.7	55.3	15.8	5.3	0.00
My students are interested to learn about evolution	6.6	21.1	19.7	40.8	11.8
All students are capable of understanding evolution	5.3	14.5	13.2	59.2	6.6

n = 76

Table 4.11 presents the frequency in percentages of teacher responses to the questions in the Evolution and Science (EAS) scale. Teachers responded to the

statement “Evolutionary topics are supported by scientific evidence” with a slight majority (59.2%) disagreeing. More teachers disagreed (75.0%) with “Evolution is a central and unifying theme in biology” and that “Evolution answers many questions about the natural world” (71.0%). These are contrasted with the majority (75.0%) of teachers agreeing that there are theories that better explain evolution. These findings are opposite of Aguillard (1999) who found that 66% of teachers agree that evolution is a central unifying theme and Bilica (2001) who found that only 22.8% of teachers agreed that there are better theories to explain evolution. Shankar and Skoog (1993) found even fewer teachers (7%) agreeing that there are better theories than evolution to explain evolution.

Table 4.11

Frequency by Percentage of Teacher Responses Reported on the Evolution and Science Dimension

Statement	Strongly Disagree	Disagree	Undecided or Don't Know	Agree	Strongly Agree
Evolutionary topics are supported by scientific evidence	32.9	26.3	9.2	23.7	7.9
Evolution is a central and unifying theme in biology	32.9	42.1	6.6	10.5	7.9
Evolution answers many questions about the natural world	35.5	35.5	9.2	11.8	7.9
There are theories other than evolution that better explain the natural world	5.3	3.9	15.8	18.4	56.6

n = 76

Table 4.12 presents the frequency in percentages of teacher responses to the questions in the Evolution and Teaching (EAT) scale. Fifty-nine percent (59.2%) of the teachers disagree with the statement that they sometimes substitute the words change over time for evolution to avoid conflicts while only 28.9% agreed. Teachers also disagreed (61.8%) with the statement “I do not teach some concepts, such as human evolution, because they are too controversial.” These two sets of data fit with the strong majority (92.1%) of teachers who say that “Evolution is a controversial concept for many people.”

Table 4.12

Frequency by Percentage of Teacher Responses Reported on the Evolution and Teaching Dimension

Statement	Strongly Disagree	Disagree	Undecided or Don't Know	Agree	Strongly Agree
I sometimes substitute the words "change over time" for "evolution" to avoid conflicts	23.7	35.5	11.8	27.6	1.3
I do not teach some concepts, such as human evolution, because they are too controversial	18.4	43.4	6.6	26.3	5.3
Evolution is a controversial concept for many people	2.6	2.6	2.6	48.7	43.4

n = 76

Table 4.13 presents the frequency in percentages of teacher responses to the questions in the School and Evolution (SAE) scale. Half of the teachers (50%) agreed while 30.3% of the teachers were undecided or didn't know if their principal supports teaching about evolutionary topics. These numbers are similar to responses to "My principal would agree that all students should learn about evolution" in that 50% agreed and 31.6% were undecided or didn't know. A simple majority of teachers (40.8%) were undecided or didn't know if their principal would ask them to de-emphasize evolution if parents protested against it, while 25% agreed and 32.9% disagreed.

Table 4.13

Frequency by Percentage of Teacher Responses Reported on the School and Evolution Dimension

Statement	Strongly Disagree	Disagree	Undecided or Don't Know	Agree	Strongly Agree
The principal at my school supports teaching about evolutionary topics	13.2	6.6	30.3	43.4	6.6
My principal would ask me to de-emphasize evolution in my class if parents protested against it	6.6	26.3	40.8	15.8	9.2
My principal would agree that all students should learn about evolution	6.6	11.8	31.6	43.4	6.6

n = 76

Table 4.14 presents the frequency in percentages of teacher responses to the statements in the Parents and Evolution (PAE) scale. A simple majority of teachers (44.7%) didn't know or were undecided in responding to "The parents at my school agree that students should learn about evolution." Only 34.2% of the teachers agreed while 21.1% disagreed. A small majority of teachers (65.8%) disagreed with the statement "I have felt pressure from the parents in my community to avoid teaching some evolution concepts" while 21.1% agreed with the statement. This level of agreement is also what Van Koevering (1989) found in Wisconsin while Tatina (1989) in South Dakota and Zimmerman (1987) in Ohio found less than 12% agreement. Finally, a slight majority (56.6%) disagreed with the statement "I have had concerned parents question me about the evolution content in my curriculum" as opposed to 36.8% who agreed.

Table 4.14

Frequency by Percentage of Teacher Responses Reported on the Parents and Evolution Dimension

Statement	Strongly Disagree	Disagree	Undecided or Don't Know	Agree	Strongly Agree
The parents at my school agree that students should learn about evolution	13.2	7.9	44.7	30.3	3.9
I have felt pressure from the parents in my community to avoid teaching some evolution concepts	22.4	43.4	11.8	15.8	5.3
I have had concerned parents question me about the evolution content in my curriculum	14.5	42.1	6.6	32.9	3.9

n = 76

Table 4.15 presents the frequency in percentages of teacher responses to the statements in the Textbook and Evolution (TXT) scale. A majority (73.7%) of teachers agreed that their textbook presents sufficient information about evolution. While a majority of teachers (59.2%) agreed that they must supplement information in their textbook to teach evolution effectively, only a slightly smaller majority (54%) disagreed with the statement "The textbook is my primary resource for teaching evolution."

Table 4.15

Frequency by Percentage of Teacher Responses Reported on the Textbook and Evolution Dimension

Statement	Strongly Disagree	Disagree	Undecided or Don't Know	Agree	Strongly Agree
My textbook presents sufficient information about evolution	5.3	14.5	5.3	56.6	17.1
To teach evolution effectively I must supplement the information in my textbook	5.3	25.0	9.2	42.1	17.1
The textbook is my primary resource for teaching evolution	14.5	39.5	6.6	34.2	3.9

n = 76

Table 4.16 presents the frequency in percentages of teacher responses to the statements in the Time and Resources (TIM) scale. Teachers disagreeing (47.4%) with the statement “In order to teach evolution comprehensively, I must eliminate other topics from my biology course” were only slightly higher than those agreeing (43.4%) with the statement. A large majority of teachers disagreed (77.6%) with the statement “I would like to emphasize evolution more, but there is not enough time available to do so” while 60.6% disagreed with the statement “The number of topics that I need to teach prevents me from emphasizing evolution more.” Bilica (2001) only found that 38% disagreed with the statement “I would like to emphasize evolution more, but there is not enough time available to do so.”

Table 4.16

Frequency by Percentage of Teacher Responses Reported on the Time and Resources Dimension

Statement	Strongly Disagree	Disagree	Undecided or Don't Know	Agree	Strongly Agree
In order to teach evolution comprehensively, I must eliminate other topics from my biology course	9.2	38.2	7.9	32.9	10.5
I would like to emphasize evolution more, but there is not enough time available to do so	27.6	50.0	6.6	11.8	3.9
The number of topics that I need to teach prevents me from emphasizing evolution more	14.5	46.1	1.3	30.3	6.6

n = 76

Five of the seven teaching influence dimension scales were found by Bilica and Skoog (2002) to have adequate reliability for scale analysis with scores ranging from 0.70 to 0.93. These dimension scales were the Personal Teaching Capacity (PTC), Student Learning (SL), Evolution and Science (EAS), School and Evolution (SAE), and Time and Resources (TIM) scales. In this study, using ANOVA, there was no significance found between teaching influence dimensions scale means and demographic categories of years of experience, gender, age, tertiary degree held, tertiary biology coursework completed, state certification, and community setting. Significant differences using ANOVA were found within specific teaching dimension category questions and demographic variables (Tables 4.17-4.22).

Table 4.17 describes the scale mean and standard deviation for gender difference to the survey statement “I have felt pressure from parents in my community to avoid teaching some evolution concepts.” Males showed a higher mean score than females in feeling this way.

Table 4.17
Mean and Standard Deviation for Gender Demographic Differences to Teaching Influence Dimension Category Statements

Question	Gender	n	Scale	Std.	F Value
			Mean	Dev.	
I have felt pressure from parents in my community to avoid teaching some evolution concepts	Males	25	2.92	1.1	4.83*
	Females	51	3.10	1.01	

*p<0.05

Table 4.18 describes the scale mean and standard deviation for age difference to specific teaching influence dimension category statements. Using the Tukey post hoc test, it was found that teachers age 21-25 scored significantly higher than teachers ages 46 and above to the statement “I would like to emphasize evolution more if I had a knowledge of it.” This could mean that the 21-25 age group feel they need more training or the 46+ group doesn’t feel an need to add more evolution emphasis. It was also found that the same groups of teachers differed significantly with regard to the statement “All students are capable of understanding evolution.” The age group 21-25 responded to this statement with greater agreement than the 46+ groups.

Table 4.18

Mean and Standard Deviation for Age Demographic Differences to Teaching Influence Dimension Category Statements

Question	Age	n	Mean	Std. Dev.	F Value
I would like to emphasize evolution more if I had a knowledge of it	21-25	10	2.90	0.99	2.82*
	26-30	17	2.41	1.00	
	31-35	13	1.84	0.55	
	36-40	6	2.17	1.17	
	41-45	7	2.43	1.13	
	46-50	14	1.71	0.61	
	50+	9	1.67	0.87	
All students are capable of understanding evolution	21-25	10	4.00	0.00	2.68*
	26-30	17	3.65	0.79	
	31-35	13	3.38	0.96	
	36-40	6	3.50	0.84	
	41-45	7	3.29	1.25	
	46-50	14	3.77	1.01	
	50+	9	2.44	1.33	

*p<0.05

Table 4.19 describes the scale mean and standard deviation for level of tertiary degree difference to specific teaching influence dimension category statements. Using the Tukey post hoc test, it was found that teachers with differing levels of degrees significantly differed on eight teaching influence dimension category statements. The most common occurrence of significant difference was between teachers with a bachelor degree plus hours and teachers with a master degree plus hours.

Table 4.19

Mean and Standard Deviation for Tertiary Degree Level Demographic Differences to Teaching Influence Dimension Category Statements

Question	Degree level	n	Mean	Std. Dev.	F Value
I am academically well prepared to teach evolution	Bachelor	14	3.43	0.94	0.01*
	Bachelor + hours	30	3.33	1.06	
	Master	16	3.88	1.20	
	Master + hours	16	4.44	0.63	
	Doctor	0	0.00	0.00	
Evolution is too complex for beginning biology students	Bachelor	14	2.36	1.01	3.19*
	Bachelor + hours	30	2.03	0.71	
	Master	16	2.19	0.66	
	Master + hours	16	1.56	0.63	
	Doctor	0	0.00	0.00	
I do not teach some concepts such as human evolution in my class if parents protest	Bachelor	14	3.36	1.15	5.51*
	Bachelor + hours	30	2.77	1.27	
	Master	16	2.25	0.77	
	Master + hours	16	1.81	1.05	
	Doctor	0	0.00	0.00	
My principal would agree that all students should learn about evolution	Bachelor	14	3.14	0.95	2.84*
	Bachelor + hours	30	3.13	1.01	
	Master	16	3.19	0.98	
	Master + hours	16	3.93	0.85	
	Doctor	0	0.00	0.00	
My textbook presents sufficient information about evolution	Bachelor	14	3.77	1.17	4.87*
	Bachelor + hours	30	4.13	0.63	
	Master	16	3.38	1.09	
	Master + hours	16	3.00	1.37	
	Doctor	0	0.00	0.00	
To teach evolution effectively I must supplement the information in my textbook	Bachelor	14	3.46	1.05	2.77*
	Bachelor + hours	30	3.03	1.03	
	Master	16	3.44	1.31	
	Master + hours	16	4.06	1.28	
	Doctor	0	0.00	0.00	
The textbook is my primary source for teaching evolution	Bachelor	14	2.54	1.33	5.74*
	Bachelor + hours	30	3.17	1.15	
	Master	16	3.00	1.10	
	Master + hours	16	1.81	0.75	
	Doctor	0	0.00	0.00	
I would like to emphasize evolution more but there is not enough time available	Bachelor	14	2.57	1.22	4.68*
	Bachelor + hours	30	1.63	0.56	
	Master	16	2.63	1.15	
	Master + hours	16	2.25	1.29	
	Doctor	0	0.00	0.00	

*p<0.05

Teachers with a master degree plus hours significantly had a higher mean for the statement “I am academically well prepared to teach evolution” than did teachers with a bachelor degree or bachelor degree plus hours. This may be due to their extra amount of education.

Teachers with a bachelor degree significantly differed from those with a master degree plus hours when responding to the statement “Evolution is too complex for beginning biology students.” The bachelor degree teachers agreed more positively with the statement than did the other group. This could be due to differing understandings of pedagogy between the groups or possibly to the different understandings of evolution.

The statement “I do not teach some concepts such as human evolution in my class if parents protest” also showed significant difference between the two groups of bachelor degree / bachelor degree plus hours and the master degree plus hours group. In this case, the master degree teachers showed less agreement that they would not teach about evolution given parent protesting. Possibly these teachers would have more experience dealing with parent issues and therefore not try to avoid such controversy.

“My principal would agree that all students should learn about evolution” was significantly more agreeable to master degree plus hours teachers than those with a bachelor degree plus hours. The former may be due to the relationship between older teachers and their administrative leaders. An older teacher would have had more time to get to know the opinions of the administration from years of collegial interaction.

Responses to the statement “My textbook presents sufficient information about evolution” fit with the responses to “To teach evolution effectively I must supplement the information in my textbook” in that in the former statement, teachers with a bachelor degree plus hours have a higher positive response where to the latter the master degree plus hours teachers have a higher positive response. Significant difference for each of these statements was only found between these two groups.

Three groups showed significant difference in response to the statement “The textbook is my primary source for teaching evolution.” The bachelor plus hours group and master degree groups showed significantly higher ratings to the master plus hours group.

In the final statement, when comparing significant differences between level of tertiary degree attainment, “I would like to emphasize evolution more but there is not enough time available,” holders of bachelor degrees and master degrees responded more favourably to the statement than teachers with bachelor degree plus hours.

Table 4.20 speaks about scale means and standard deviation between graduates of the Concordia University system and graduates of other universities. In three of the cases where there was a significant difference, the graduates of the Concordia University system agreed at a higher mean than non-graduates. In response to the statement, “My textbook is my primary source for teaching evolution” the non-graduates responded in a significantly more favourable way.

Table 4.20
Mean and Standard Deviation for Concordia University System Demographic Differences to Teaching Influence Dimension Category Statements

Question	Concordia University system status	n	Mean	Std. Dev.	F Value
My students are interested to learn more about evolution	Graduate	36	3.61	0.99	5.38*
	Non-Graduate	40	3.03	1.88	
All students are capable of understanding evolution	Graduate	36	3.72	0.91	4.20*
	Non-Graduate	40	3.26	1.04	
To teach evolution effectively I must supplement the information in my textbook	Graduate	36	3.75	1.13	5.82*
	Non-Graduate	40	3.10	1.19	
The textbook is my primary source for teaching evolution	Graduate	36	2.44	1.16	4.18*
	Non-Graduate	40	3.00	1.19	

*p<0.05

Table 4.21 describes the mean and standard deviation for teachers’ amount of completed coursework credit hours in biology to specific teaching influence dimension category questions. Using the Tukey post hoc test it was found that teachers with 1-5 hours of course work had a significantly lower mean than all the

other groups in response to the statement “I am academically well prepared to teach evolution.” In the other two statements “I am academically well prepared to teach evolution” and “I am confident in my ability to teach evolution effectively,” no single group showed an outstanding significant difference from the others.

Table 4.21

Mean and Standard Deviation for Completed Biology Coursework Credit Hours Demographic Differences to Teaching Influence Dimension Category Statements

Question	Biology Coursework credit hours completed	n	Mean	Std. Dev.	F Value
I am academically well prepared to teach evolution	0	2	4.00	0.00	2.48*
	1-5	3	3.33	0.58	
	6-12	9	3.44	1.24	
	13-19	6	3.17	1.33	
	20-26	13	3.31	1.25	
	27-33	7	3.00	1.00	
	33 +	36	4.14	0.83	
I am confident in my ability to teach evolution effectively	0	2	4.00	0.00	2.41*
	1-5	3	3.33	0.58	
	6-12	9	3.25	1.28	
	13-19	6	3.00	1.26	
	20-26	13	3.15	0.99	
	27-33	7	3.71	0.95	
	33 +	36	3.94	1.01	
Evolution is a very controversial concept for many people	0	2	5.00	0.00	3.50*
	1-5	3	2.33	1.15	
	6-12	9	4.33	1.00	
	13-19	6	4.17	0.41	
	20-26	13	4.38	0.87	
	27-33	7	4.29	0.49	
	33 +	36	4.36	0.76	

*p<0.05

Table 4.22 shows that teachers who are certified in their own state agreed with the statement “I am academically well prepared to teach evolution” significantly more than those not certified by their local state to teach biology. This could have to do with state requirements to take coursework or complete examinations based on evolution.

Table 4.22

Mean and Standard Deviation for State Certification Demographic Differences to Teaching Influence Dimension Category Statements

Question	State Certified to Teach Biology	n	Mean	Std. Dev.	F Value
I am academically well prepared to teach evolution	Yes	52	3.90	1.02	6.57*
	No	24	3.25	1.07	

*p<0.05

4.5.3 Comments from Teachers

The TETS survey included an optional comments section where teachers were able to offer any comments regarding the survey. They were allowed to use separate sheets of paper if not enough space was available.

Out of the 76 teachers who returned completed surveys 53 of them chose to fill in the optional comments section. Two surveys which were returned, but not used for analysis since the first three sections had not been filled out, had comments written upon them which can be seen in the teacher comments appendix as well. Any comments which could identify a particular teacher or identifiable group of teachers have been edited to retain anonymity (*Appendix G*).

Four types of comments were made multiple times. Of the 53 surveys, 42 had commentary to the idea that the teacher taught about evolution, but did not believe in it. Likewise, 36 teachers wrote comments saying that they believed in creation. Ten (10) of the comments alluded to the idea that definition of the terms of evolution need to be very precise. Six (6) of the respondents noted that their answers in section 1 of the TETS survey were the same for current level of teaching and preferred level of teaching since they have the choice already.

4.6 Summary

This chapter reported statistical description and analysis of the responses of students and teachers to the TOSRA and TETS surveys respectively.

To answer the study aims, two analysis were done using the TOSRA data. The reliability of the TOSRA was measured for Lutheran school students in the pacific southwest United States. Analysis was done to find whether significant change in

student attitudes occurred regarding the seven scales of the TOSRA in a pre-test/post-test study where the intervention was a biology class unit on evolution.

Statistical description and analysis was done with the TETS data to investigate the aims of the study. Descriptive statistics were reported for teacher emphasis on the seven fundamental scales of evolution and eight teacher influence dimension scales. Analysis were also done to determine if significant differences were present between demographic variables and those scales. In addition, summary of the qualitative data from the free comments section of the TETS was described.

The following chapter will provide a summary of the conclusions from this data.

CHAPTER 5

Conclusions

5.1 Introduction

This chapter provides a summary and synthesis of the findings of this research into evolution education in parochial schools. The data collected regarding the research questions in Chapter 3 are discussed. From this discussion, conclusions are drawn, implications for teachers are shown, the implications of the study are discussed, future directions for research are suggested and concluding remarks are made.

Chapter 1 introduced this study by outlining the history, background, significance, and origins of this study. Chapter 2 provided a literature review of the prior studies in the fields of evolution, evolution education, and learning environments research. Chapter 3 outlined the methodology of the study including validation from previous studies of the data gathering instruments, their usage, and the rationale for their usage in this mainly quantitative study. Chapter 4 presented the data regarding the validation of the instruments in this study. Data were also shown regarding change in student attitudes, teacher emphasis on evolution, factors influencing teachers, and statistical connections between teacher demographics and their emphasis on evolution.

5.2 Major Findings of the Study

There were six research questions guiding this study. Each of them is addressed here with regard to the results.

Research Question #1- Is the TOSRA a valid and reliable instrument for testing science attitudes of parochial school students in the USA?

The results of this study show that the TOSRA is a valid and reliable instrument for use in parochial schools in the USA. The alpha reliabilities for the seven scales of the TOSRA were between 0.70 and 0.93. These figures are considered appropriate for the internal consistency of an attitudes survey according to a scale produced by Vierra, Pollock, and Golez (1998). The figures are also consistent with reliabilities

found by Smist (1994) and Fraser (1981) for reliability of the TOSRA with American students.

Research Question #2- Does exposure to evolution education change the science attitudes of Lutheran high school biology students?

The results of the study show that student attitudes toward science do change once they have participated in a unit on evolution in their basic secondary school biology class. The statistics for the paired sample t-test showed significant differences between the pre-test and post-test scores of the Lutheran high school biology students in their attitudes toward four of the seven scales of the TOSRA. Students' attitudes changed with regard to the Normality of Scientists, Scientific Inquiry, Adoption of Scientific Attitudes and Leisure Interest in Science scales.

The changes in attitudes did not all change in a positive way. Student attitude means toward the Normality of Scientists and Leisure Interest in Science increased while the means for student attitude toward Scientific Inquiry and Adoption of Science Attitudes decreased.

The positive changes in attitudes regarding the Normality of Scientists may be the result of learning more about specific scientists including Darwin and others in the field of evolution. When the students learn about the life of a particular scientist and the experiences the scientist had, students transform the idea of a "scientist" from the stereotypical nameless person in a white lab coat, to that of a real person with thoughts and feelings. This would cause the student to relate better to scientists and see that they are similar to him or herself. This in turn would result in a more positive attitude toward the Normality of Scientists.

The positive change in attitudes toward Leisure Interest in Science may be the result of the religious interaction of evolution and creation. High school age students are creating their world view and defining themselves. Part of their move toward independence is to formulate opinions on topics of interest so that they can speak to the topic if it were to arise in conversation. When concepts are perceived to conflict, such as with evolution and creation, students must somehow reconcile the situation. Because the topic of evolution is controversial, this may have caused piqued interest

in science for the students, as they could see application of the information in their life outside of school, thus increasing their Leisure Interest in Science.

The negative changes in attitude toward Inquiry in Science and Adoption of Scientific Attitudes may have been caused by the pedagogy used to present the material. Typically science classes are taught using the direct instruction, lecture model which is not student centred. Laboratory exercises are often the highlight of a unit, however, in the case of a unit on evolution, evolving of species laboratory exercises cannot be done within the confines of the class period. If the teacher does not investigate interesting ways to present the material, students will lose interest. It is possible that the students did not feel challenged to use inquiry based skills as a part of the unit and thereby did not construct greater Scientific Attitudes.

Research Question #3- To what degree do Lutheran secondary school teachers incorporate evolution in their teaching of basic first year biology courses?

It was found that all Lutheran secondary school teachers teach some aspects of evolution while they do not all teach every aspect of evolution. This teaching of evolution also cannot be interpreted as teaching for student belief since the survey questions were not designed to test this concept. This was also shown to be the case from the written teacher comments in section four of the survey where forty-two of the teachers wrote comments saying that “the purpose of this [teaching of evolution] is not to prove evolution, but rather teach what evolution says.”

Natural Selection, Diversity of Organisms, and Speciation are emphasized at a higher frequency than are Evidence for Evolution, Pace and Rate of Evolution, Descent with Modification, and Human Evolution. The high teacher emphasis on diversity and natural selection could be the result of the lack of controversy over those topics due to the abundant living examples in nature of these concepts and the lack of a seemingly alternative examination of the topics in the Bible. The diversity and similarity of organisms can be seen, for example, in the wide variety of animals and plants on earth, while at the same time those organisms are formed from the same basic structures of DNA nucleotides. Natural selection is seen in the hunting

patterns of predators where the weak and the defenseless are culled from populations leaving the organisms most adept at surviving to breed and create the new generation. There is little doubt regarding the validity of these concepts and therefore they are covered in greater frequency in biology classrooms.

Human Evolution, Descent with Modification, and the Pace and Rate of Evolution are the most controversial concepts of evolution and therefore could cause the lack of emphasis on these topics. Creationists using a strict interpretation of the Bible would not validate the naturalistic view of man being descended from lower primates over millions of years. Because the current naturalistic and popular creationist views conflict, teachers may find it easier to downplay or avoid the topics of human evolution, descent, and the rate of evolution. Covering these topics in the classroom may move into areas of debate and opinion in which the teachers are not comfortable, confident, or trained.

Evidence for evolution as a topic can be difficult for Lutheran high school teachers to teach since presenting such evidence could be considered by some as trying to indoctrinate students with evolutionist thinking. This concern can be seen in the comments section of the TETS survey where forty-two of the comments addressed the idea that teachers present the material, but not because they believe the material about evolution. These teachers present evolution in a manner so that students can learn about the theory as it would be presented in a public high school or later in their academic career.

Presenting evidence of evolution as an academic exercise is very important when teaching in the biological sciences. As a naturalistic theory, it is the best explanation for the present state of the living world. It does have areas where more research or different methods need to be used to find the truth about the living world. To leave out any mention of evolution and its workings in a biology class would be denying students the ability to understand the process of science and how it has been applied in the biological world.

This idea that presenting evolution as a necessary part of a biology class must not be construed as a mandate for believing the ideas about evolution without any question to their veracity. Students need to be trained in scientific thinking. They need to

know how to distinguish between strong and weak evidence, and between strong and weak arguments. Students need to be taught that science has particular strengths in observation and methodology for discovery, while it cannot determine moral and ethical standards. It is important that these ideas are taught so that students can be independent thinkers and move toward better understanding of biological debate and research.

Research Question #4- What is the amount of emphasis given by Lutheran biology teachers to the seven fundamental concepts of evolution as compared to the amount of emphasis they would place on each concept given unlimited freedom to decide the curriculum?

Lutheran biology teachers showed a significant difference between their current and preferred emphasis in teaching the seven fundamental concepts of evolution. In each scale, it was found that teachers would like to increase their amount of time spent on the topic. This fits with the previous study in Texas schools by Bilica (2001) where teachers also showed a significant propensity for increasing the amount of emphasis placed on each of the topics of evolution.

These findings can also be taken in light of the six write-in comments made in section four of the TETS survey. These six teachers made the point that they already have complete control over the amount of time they spend on any particular subject in their class. One teacher said “My answers are the same [in the first section] because I feel I have unlimited freedom [to choose what I will teach].” These teachers had the same scores for current emphasis and preferred emphasis for each of the seven fundamental concepts of evolution. Their personal control of content is related to the lack of school board and state board oversight for private schools. If the public school teachers were given such freedom, the results of previous studies may have been different.

Research Question #5- How do Lutheran biology teachers compare to public school teachers in their emphasis of evolution education in their classroom and the influences which guide their decisions?

Lutheran biology teachers hold many of the same opinions as public school teachers regarding their emphasis of evolution in the classroom and the influences guiding their decisions. There are teachers who feel that evolution education is an important concept in light of a well based biological education. There are teachers who feel that evolution is too controversial to speak much about it, and there are teachers who would rather emphasize only parts of the concepts of evolution rather than the whole theory. These sentiments were found in the literature review of previous studies on public school teachers in various states. The only major disagreements between the current study and the previous studies were in the ideas of whether students could understand the concept of evolution and teachers' opinion of whether there are theories which better explain evolution.

Lutheran biology teachers had responses to seven of the eight teaching influence dimension scales questions that were very similar to those responses of public school teachers in most previous studies. In the Personal Teaching Capacity scale, a majority felt they were academically prepared to teach evolutionary concepts. The Evolution and Teaching scale responses showed that teachers in both Lutheran schools and the public schools do avoid evolutionary concepts that are controversial. Teachers from both groups generally feel the same that they aren't completely sure of the opinion their administration has on the teaching of evolution in the School and Evolution scale. There was a very strong similarity in teacher responses to the Parents and Evolution scales and the degree of influence between this study and those done in various state public schools where teachers weren't sure of parent opinion of the teaching of evolution in school. Teacher responses to the Time and Resources scale were also close to that of their public counterparts although more Lutheran teachers would like more time to emphasize evolution than do public school teachers. Finally, responses on the Textbooks and Evolution scales were similar between previous studies and the Lutheran teachers in this study where they use quite a bit of the textbook resources for their information. Each scale comparison revealed great similarity between the sentiments of public and parochial school teachers in their revealing of factors which influence them in the decisions they make on their emphasis on evolution in the classroom.

For the idea that “students are capable of understanding evolution,” the previous study on Texas schools by Bilica (2001) found that teachers believed this at nearly the same rate as the Lutheran teachers although Aguillard’s (1999) study in Louisiana had half the positive response rate. This could be attributed to the different survey used in the Aguillard study compared to the TETS survey used in this study and Bilica’s. These questions in these surveys may not have been worded in a way which would evoke the same teacher response. Further studies using linked questionnaires could show possible causes or reasons for this variation

The teaching influence dimension that did not show similar responses between previous studies and this study was the Evolution and Science scale. Lutheran teachers felt that there are better theories than evolution to explain the biological world around us which was opposite to the studies by Bilica (2001), Aguillard (1999), and Shankar and Skoog (1993). This difference is attributed to the Christian emphasis at Lutheran schools of Biblical teaching about the origins of life. This explanation is supported by thirty-six teacher’s written comments which put forward that creation is a valid explanation for origins and evolution. Some examples of those comments are:

I teach my students about the theory of Evolution. ... I am a creationist and so are my students.

We teach evolution not as truth, but as another scientific theory that should be tested continually. We hold true that science is a man-made endeavour, and that only God's inerrant Word in the Bible is truth. We believe that God created humans, animals, plants, and all other life with order and with a specific purpose in mind, not that life has come about by chance and that we all wander around this earth with no purpose....

I teach in a school where a creation-oriented textbook is used. ... I believe it is important that students are knowledgeable about evolution....

I teach a two week unit on evolution and creation we study both sides to all theories. We use lots of journal articles to find what

they do here scientific proof for and what is still vague or unexplained.

I believe it is important for students to learn about evolution in a Christian setting and how to stand up for their creationist beliefs in a non-Christian setting.

Our school is firmly committed to believing in creation and learning about all organisms as incredible creations of God. I use things like speciation and adaptation....

We do discuss evolution as a theory that is widely accepted in the scientific world, but again that we believe in creation.

I teach Evolution as compared to creation. Students need to know both concepts as Christian students.

I teach from a creationist view point, but I think knowing both sides of the issue are important....

These comments show that these teachers are committed to knowledge of the subject of evolution, but not necessarily the belief in evolution.

These results show that the two “camps” on belief in evolution may not be so far apart regarding evolutionary teaching. Teachers in both public and private schools face many of the same influences regarding their teaching. Both groups see a need for teaching about evolution. The setting of the school, Lutheran or public, doesn’t have an impact on what influences teachers. This may be from the reality that the constituency for both types of schools is a combination of Christian and non-Christian students. This shows that it would be prudent for science educators to work together for better understanding of the scientific world and how it interacts with other disciplines which may seem to conflict.

Research Question #6- Do demographic characteristics of gender, years of teaching experience, age, highest tertiary degree held, completed tertiary biology coursework, location of tertiary

work, state certification, or community setting influence
Lutheran teacher emphasis on evolution?

No significant differences were found between demographic groupings of gender, years of teaching experience, age, highest tertiary degree held, completed tertiary biology coursework, location of tertiary work, state certification, or community setting and the scales of factors influencing teacher evolution emphasis. Only the Personal Teaching Capacity, Student Learning, Evolution and Science, School and Evolution, and Time and Resources scales were used in this analysis. The Evolution and Teaching, Parents and Evolution, and Textbook and Evolution scales were not used due to a low reliability for these factors. These findings reveal that Lutheran teachers generally hold similar views of evolution which are not different from a random sample population of public teachers.

The only significant differences found in section two of the TETS survey were in comparing specific statements from the influence dimension scales and demographics. These differences are not significant to the outcomes of the study since individual questions do not encompass the context of the scales. An example of this is shown when teachers responded to the statement “My principal would agree that all students should learn about evolution.” An individual teacher will try to define whether the principal is considering the ideas of human evolution and pace and rate of evolution rather than natural selection. The teacher also may be working through whether the principal would like evolution taught as the only answer to investigations of life science or one of many ways we learn about living things. The statement of the principal agreeing becomes a difficult question to assess since it is the teachers’ opinion of another person’s thoughts. Although there was significance in some statements, they do not hold value to the larger outcomes of this study.

5.3 Implications of this Study

This research has implications for multiple audiences. The findings from the study relate to ideas about curriculum, teacher attitudes, student attitudes, teacher training, and evolution pedagogy.

This research has shown that through teaching, student attitudes toward science can change. Science classes are typically avoided by students out of fear that the subject

matter is too difficult. The result in the USA has been a decrease in enrolment in secondary school physics and chemistry classes which are usually taken by 11th and 12th grade students. In taking only a minimal number of science classes, these students limit their knowledge about science and also perpetuate stereotypes of science being only of interest for people in lab coats. More time in pedagogically sound science classes could help eliminate those stereotypes and provide time for students to wrestle with the material and find its personal practical use.

Student attitudes are malleable. This study has shown that within the timeframe of a unit on evolution in a first year biology class, students' attitudes toward science change both positively and negatively. Considering that attitudes were measured based on only one unit out of the many taught in a first year science class, it can be inferred that more class time spent in science subjects could result in continuing changes of students' attitudes toward science. It is necessary to isolate the causes of the changes in attitudes to promote those factors which caused a positive change in attitudes and discourage those that caused a negative change in student attitudes.

Teachers use a variety of systems for teaching science concepts. The teachers instructing students taking part in the TOSRA portion of this study did not confer with one another about how to teach the material on evolution, but as a collective group, their students' attitudes changed. No single pedagogical method for teaching about evolution caused the change in student attitudes. There were aspects of pedagogy from each teacher which influenced the students' attitudes toward science. Designing a curriculum based upon the styles of these teachers can result in a focused curriculum which will change students' views toward science.

The results of this study indicate that teachers in Lutheran schools are very similar to their public counterparts in their emphasis on evolution in the classroom. This is very significant for three reasons. First, research which uses the parochial school population may have a broader application than revealed in this study. This study used quantitative analysis from Lutheran high school teachers across the USA. Being a small population, the levels of significance are small. If the study were done nationwide across the entire parochial school sector and internationally, and the results still mirror studies done in public schools, then the parochial schools

could become a valid sample population for future studies on teacher emphasis of evolution.

The study also has importance, in showing that Lutheran high school teachers and public school teachers are very similar in their emphasis on evolution, because anecdotal misconceptions about the pedagogical practice in private schools have been perpetuated through the lack of empirical evidence to the contrary. This study describes the actual state of pedagogy in the parochial school in relation to teachers' emphasis on evolution. The data indicate that teachers in parochial and public schools are similar in their pedagogical decisions. These data may be used to strategize how to best teach students in evolution education no matter which school, public or private, they are in.

Finally, because there are so few studies regarding parochial school pedagogy as compared to public schools, this study is a gateway to learning about an important yet underrepresented population of teachers and students within the science education community. Researching parochial teachers and students ensures a more accurate description of the whole learning community rather than just the most dominant part.

Teachers in public schools and Lutheran schools have very similar influences on their choices in teaching evolution and also have made similar choices in their emphasis on evolutionary topics. The underlying goal of teaching evolution may be different in terms of knowledge rather than belief, but the teachers in the Lutheran schools are not much different than their public school counterparts in the time spent on particular evolutionary topics, nor in what influences their teaching decisions. New curriculum can be created to satisfy not only the needs of the public school teachers in evolution, but also the new materials can be created to meet the very similar needs of private school teachers.

Pre-service and In-service teachers will benefit from this research by examining how their personal beliefs fit with prevailing attitudes and emphasis on evolution. As seen from the collected data, teachers hold a wide range of beliefs on their emphasis on the topic of evolution. It would be important for teachers to gather to discuss how they make their decisions about teaching evolution, and to discuss why they

decide in the way that currently do. In the rather autonomous profession of teaching, it is difficult for teachers to observe others. This study provides a glimpse into the practices of parochial school teachers which can be used by all teachers.

5.4 Limitations of this Study

This study is limited by its size and scope. The sample population of students is valid for the states in which the study was conducted. Extrapolation to larger populations outside the geographic areas of California, Arizona, and Nevada would need more verification especially considering the small significance sizes of the differences found in the statistical analysis.

The study is also limited in that the teacher survey represents Lutheran school teachers who responded to the survey. Other religious groups operating secondary schools may have different fundamental beliefs that would skew the responses to the questions. The study also represents only 60% of the Lutheran teachers. Non-respondent teachers could have significantly different responses to the current totals.

Finally, this teacher survey is limited in that only five of the eight teaching influence dimension scales were found to have adequate reliability. All the scales were represented with descriptive information, but only the five scales with adequate reliability, Personal Teaching Capacity, Student Learning, Evolution and Science, School and Evolution, and Time and Resources, were used for statistical analysis. It would be helpful for future studies to refine these scales for internal consistency.

5.5 Future Directions and Further Research

Future research could seek to conduct observational analysis and interviews with students to explain what caused changes in attitudes and the techniques teachers can use to generate those outcomes. To allow for complete anonymity, the student survey section of this study using the TOSRA did not include gathering of qualitative data through interview and observation. Future research should include what Johnson and Onwuegbuzie (2004) call "Mixed Methods Research" where qualitative research design can be used to explain the data from the quantitative design. Data would be collected from willing participants and would delve further into the reasons for attitudinal change. Tracking of the pedagogy used in classrooms

where students' attitudes toward science changed will provide information useful for teacher training. Studies of this type will then be used to create teaching materials which will promote positive changes in student attitudes toward science.

Future research regarding teacher emphasis and influences on teaching evolution would be bolstered using mixed methods as well. Although qualitative data were obtained in this study, observational analysis and interviews with teachers would provide specific information about the reasons for teachers emphasizing topics in evolution more than others and what influenced them to make those decisions. This information can then be used to guide teacher training in the biological sciences for pre-service and in-service teachers.

Future research could also seek to establish curriculum, which would be offered at all Lutheran schools. This curriculum could focus on the most emphasized concepts of evolution education while increasing the potency of the least emphasized concepts. The unification by common curriculum may help improve the confidence in the teaching of evolutionary topics as well as allow for more collaboration in teaching.

Future research should broaden the teacher study group by incorporating the Catholic school system and other private educational institutions. This study focuses on the Lutheran High School system in the USA since it is the second largest private secondary school system in the nation. Using the same teacher surveys with the larger population would add useful data to the knowledge we currently have about evolutionary teaching in schools. Data on teacher pedagogical emphasis are not complete without sampling this important population.

Expanding the study student population is an important future focus of research. The data collected for this study were from students attending Lutheran high schools in the geographic areas of California, Arizona, and Nevada. Future studies should include Lutheran students across the USA rather than the south west corner. In addition, data should be collected from students in the Catholic system and at other private institutions. The millions of students served by these entities are not represented in the research data pool thus far. Including this larger group will

provide a clearer picture of students' attitudes toward science and increase the generalizability of the data.

Studying students and teachers internationally is an important continuation of this study on evolution education. As was discussed in Chapter 2, the controversy over teaching evolution has been centred in the USA, but has been steadily moving into pedagogical discussion in other parts of the world. It is important that this topic be studied as it migrates through different traditions and cultures. Differing world views will reveal ideas about the topic that had not previously been considered. Incorporation of a multinational perspective will bring to light the optimal pedagogical techniques for teaching evolution.

Continuing research should be done to refine the TETS survey instrument. Only five of the eight teaching influence dimension scales were found to have adequate reliability. The scale sizes can be expanded to increase the differentiation between the scales. The questions in the scales can also be enhanced for clarifying the definitions of the concepts which are covered in the survey instrument. These refinements will improve the instrument.

5.6 Chapter Summary and Concluding Remarks

This thesis has studied the condition and effects of evolution education in the parochial school. It has provided reliability and validity data regarding the use of the TOSRA and the TETS surveys in Lutheran Secondary schools in the USA. The results have also shown that all teachers in Lutheran secondary schools do teach about aspects of evolution in their classrooms, although the amount is not consistent between teachers. It was also found that Lutheran High school students who participate in a unit on evolution in their first year secondary school biology class can significantly change their attitudes toward science. This information is useful for future research into how evolution should be taught to positively affect students' attitudes and how to write useful curriculum which teachers will feel comfortable in teaching.

The motto "Good teaching is good teaching" finds its place within this study. It is important to understand that "classroom materials designed to involve pupils in discussion and application are not enough if the teacher's strategy is not

appropriate” (Aleixandre, 1994, p. 533). To affect students’ attitudes we must demonstrate appropriate pedagogy in causing change. Good teaching is difficult to accomplish without proper training and practice (Linhart, 1997). Therefore, our continuing goal is to create materials and methods through future studies that will create more positive attitudes toward science and the specific topics within science.

It is important to study topics such as evolution in the light of the so called “opposition” just as it is important for debaters and lawyers to get to know the facts from both positions so that they can come to truth. Much of the fanfare regarding the controversy of evolution comes from anecdotal evidence, second-hand information, and opinion. By studying a topic, using appropriate research methods, we can focus on working toward truth and move away from the feelings driven argumentativeness of the current evolution debates.

In a personal note regarding this project, I have had various interesting responses to my researching such a controversial subject, both from peers in the Lutheran sector and from the secular sector. Most commonly others will say that it was “very gutsy” to research the subject since the backlash could be great from both the extreme conservatives as well as from the extreme secularists. To that point, I would like to note that this research must not be misused to try to persecute any teacher who teaches about evolution in the Lutheran schools. This would be as logical as removing teachers of world religions classes who teach about the different religious groups. This was addressed in one of the teacher comments saying:

In my school (Wisconsin Evangelical Lutheran Synod), the history teacher teaches about Moslem religion. In religion class, students learn about other denominations (even cults). I teach all students need to know about evolutionary theory. They need to know as much or more than the average student. I teach them that evolutionary theory is the best explanation humans- using their reason- can put forth. It is logical, scientific, and as supported as any theory in any field. The difference is that Christians view the world as created by God. Evolutionary theory is the explanation that works if no faith in God is present.

Conversely, it would be inappropriate to use this information to say that religious institutions are moving away from creationist beliefs and espousing full belief in evolution. We must strive to understand the different knowledge domains of science and religion and use each field's unique and important features to find truth. In my use of anonymous survey instruments, I hoped to create a safe environment for the respondents so that they could answer truthfully and without fear of retribution or misinterpretation of their responses. As with any piece of legitimate research, the results of this project must be taken at face value, and interpretations must be logically valid and true to the given data.

References

- AAAS statement on the Kansas state board of education decision on the education of students in the science of evolution and cosmology. (1999). *Science*, 286(5445), 1754.
- Aguillard, D. (1999). Evolution education in Louisiana public schools: A decade following Edwards v. Aguillard. *The American Biology Teacher*, 61(3), 182-188.
- Aikenhead, G. S. (1997). Student views on the influence of the culture of science. *International Journal of Science Education*, 19(4), 419-428.
- Alexandre, M. P. J. (1994). Teaching evolution and natural selection: A look at textbooks and teachers. *Journal of Research in Science Teaching*, 31(5), 519-535.
- Alles, D. L. (2001). Using evolution as the framework for teaching biology. *The American Biology Teacher*, 63(1), 20-23.
- Amendment to House Bill No. 197, Oklahoma House of Representatives: Oklahoma(1923).
- American Association for the Advancement of Science. (1990). *Science for all Americans*. New York: Oxford University Press.
- American Association for the Advancement of Science. (1993). *Benchmarks for science literacy*. New York: Oxford University Press.
- Ayala, F. J. (2000). Arguing for evolution. *The Science Teacher*, 67, 30-33.
- Bandura, A. (1977). *Social learning theory*. Englewood Cliffs, NJ: Prentice-Hall, Inc.
- Bandura, A. (1986). *Social foundations of thought and action*. Englewood Cliffs, NJ: Prentice Hall.
- Bandura, A. (1997). *Self efficacy: The exercise of control*. New York: W.H. Freeman.
- Barry, A. L. (2000). *What about creation and evolution*. St. Louis, MO: Office of the President, The Lutheran Church Missouri Synod.
- Barry, E. (2004). Schools chief's viewpoint evolves. *Los Angeles Times*, p. 1.
- Benen, S. (2001). Age-old controversy. *Church & State*, 54(1), 12.

- Bergman, J. (1993). A brief history of the modern American creation movement. *Contra Mundum*, 7, 22.
- Bilica, K. L. (2001). *Factors which influence Texas biology teachers' decisions to emphasize fundamental concepts of evolution*. Unpublished dissertation in curriculum and instruction, Texas Tech University, Lubbock.
- Bilica, K. L., & Skoog, G. D. (2002, April). *Factors which influence Texas biology teachers' descisions to emphasize fundamental concepts of evolution*. Paper presented at the National Association for Research in Science Teaching, New Orleans.
- Blackwell, W. H., Powell, M. J., & Dukes, G. H. (2003). The problem of student acceptance of evolution. *Journal of Biological Education*, 37(2), 58-67.
- Branch, G., & Scott, E. C. (2003). The antievolution law that wasn't. *The American Biology Teacher*, 65(3), 165-166.
- Brooks, D. J. (2001). *Substantial numbers of americans continue to doubt evolution as explanation for origin of humans*. Retrieved March 5, 2001, , from University of Nebraska, Lincoln Web site: www.unl.edu/rhames/courses/current/creation/evol-poll.htm
- Brown, F. S. (1996, April). *The effect of an inquiry-oriented environmental science course on preservice elementary teachers' attitudes about science*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, St. Louis.
- Brummett, J. (1981). He hasn't read it, but White signs bill on "creation." *Arkansas Gazette*, (20 March 1981), p. A1.
- Carlesen, W. S. (1991). Effects of new biology teachers' subject-matter knowledge on curricular planning. *Science Education*, 75, 631-647.
- Carpenter, C. (1963). *History of American schoolbooks*. Philadelphia: University of Pennsylvania Press.
- Chapman, J. (2001). Creationism takes root where Europe and Asia meet. *Skeptical Inquirer*, 25(5), 77.
- Charles who?. (2000). *New Scientist*, 167(2257), 5.
- Cherif, A., Adams, G., & Loehr, J. (2001). What on earth is evolution? *The American Biology Teacher*, 63(8), 569-592.
- Clough, M. P. (1994). Diminish students' resistance to biological evolution. *The American Biology Teacher*, 56(7), 409-415.

- Cobern, W. W. (1994). Point: Belief, understanding, and the teaching of evolution. *Journal of Research in Science Teaching*, 31(5), 583-590.
- Colorado a victory for science. (1999). *Skeptic*, 7(4), 14.
- Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16, 297-334.
- Crowl, T. (1996). *Fundamentals of educational research* (2nd ed.). New York: Brown & Benchmark.
- Cummins, C. L., Demastes, S. S., & Hafner, M. S. (1994). Evolution: Biological education's under-researched unifying theme. *Journal of Research in Science Teaching*, 31, 445-448.
- Dagher, Z. R., & BouJaoude, S. (1997). Scientific views and religious beliefs of college students: The case of biological evolution. *Journal of Research in Science Teaching*, 34(5), 429-445.
- Dobzhansky, T. (1973). Nothing in biology makes sense except in light of evolution. *The American Biology Teacher*, 35, 127-129.
- Does a charter school have to teach evolution. (2000). *Curriculum Administrator*, 36(9), 3.
- Downie, J. R., & Barron, N. J. (2000). Evolution and religion: Attitudes of Scottish first year biology and medical students to the teaching of evolutionary biology. *Journal of Biological Education*, 34(3), 139-146.
- Edwards v. Aguillard (482, U.S. 578, 55 (1987) U.S. Law Week 4860, S. CT. 2573, 96 L. Ed 2d510 1987).
- Eglin, P. G. (1983). *Creationism vs. evolution: A study of the opinions of Georgia science teachers*. Unpublished Doctoral dissertation, Georgia State University, Atlanta.
- ELCA schools. (2004). Retrieved March 29, <http://wwwtest.elca.org/schools/questions.html>, 2004
- Ellis, W. E. (1986). Creationism in Kentucky: The response of high school biology teachers. In R. W. Hanson (Ed.), *Science and creation: Geological, theological, and educational perspectives* (pp. 72-91). New York: Macmillan.
- Epperson v. Arkansas (393 U.S. 97. (1968).
- Esbenshade, D. H. (1993). Student perceptions about science and religion. *The American Biology Teacher*, 55(6), 334-338.

- Evans, M. E. (2001). Cognitive and contextual factors in the emergence of diverse belief systems: Creation versus evolution. *Cognitive Psychology*, 42, 217-266.
- Farber, P. (2003). Teaching evolution and the nature of science. *The American Biology Teacher*, 65(5), 347-354.
- Fraser, B. J. (1981). Test of science-related attitudes. *Melbourne: Australian Council for Educational Research*.
- Fraser, B. J. (1994). Research on classroom and social climate. In D. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 493-541). New York: Macmillan.
- Fraser, B. J., & Walberg, H. J. (1981). Psychosocial learning environment in science classrooms: A review of research. *Studies in Science Education*, 8, 67-92.
- Fysh, R., & Lucas, K. B. (1998). Science and religion: Acknowledging student beliefs. *Australian Science Teachers Journal*, 44(2), 60-68.
- Goh, S. C.-Y., Young, D. J., & Fraser, B. J. (1995). Psychosocial climate and student outcomes in elementary mathematics classrooms: A multilevel analysis. *Journal of Experimental Education*, 64, 29-34.
- Gold, S. (2003a, November 6). Religion, science may turn a page over textbook in Texas. *Los Angeles Times*, p. A11.
- Gold, S. (2003b, November 7). Vote in Texas is one for the science books. *Los Angeles Times*, p. A38.
- Good, R. (2003). Evolution and creationism: One long argument. *The American Biology Teacher*, 65(7), 512-516.
- Grobman, A. B. (1969). *The role of biological science curriculum study*. Garden City, NY: Doubleday.
- Helms, J. V. (1998). Science and me: Subject matter and identity in secondary school science teachers. *Journal of Research in Science Teaching*, 35(7), 811-834.
- Hoff, D. J. (2000). Most states get satisfactory rating on evolution content. *Education Week*, 20(5), 24.
- Holden, C. (1990). Sudanese scientists detained. *Science*, 248(4952), 167.
- House Bill No. 185, Tennessee House of Representatives: Tennessee(1925).
- House concurrent resolution No. 7, Florida House of Representatives: Florida(1923).

- Jefferey, K. R., & Roach, L. E. (1994). A study of the presence of evolutionary protoconcepts in pre-high school textbooks. *Journal of Research in Science Teaching*, 31(5), 507-518.
- Johnson, P. E. (1993). *Darwin on trial* (2nd ed.). Downers Grove: InterVarsity Press.
- Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, 33(7), 14-26.
- Kansas evolution battle spreads to Kentucky, New Mexico schools. (1999). *Church & State*, 52(10), 17.
- Karpenko, B. (2004). *Directory of lutheran high schools*. Retrieved August 20, 2003, <http://www.valpo.edu/lutheran/lhsdir/>
- Keown, D. (1988). Teaching evolution: Improved approaches for unprepared students. *The American Biology Teacher*, 50(7), 407-410.
- Kirk, R. E. (1995). *Experimental design: Procedures for the behavioural sciences* (5 ed.). Pacific Grove: Brooks/Cole Publishing Company.
- Klopfer, L. E. (1971). Evaluation of learning in science. In H. J. Walberg (Ed.), *Handbook on summative and formative evaluation of student learning*. New York: McGraw-Hill.
- LaPlante, J. (1981, July 22, 1981). Gov. Treen signs measure requiring creationism lessons. *State-Times*, p. 1.
- Larson, E. J. (1989). *Trial and error: The American controversy over creation and evolution*. New York: Oxford University Press.
- Lawson, A. E. (1999). A scientific approach to teaching about evolution and special creation. *The American Biology Teacher*, 61(4), 266-274.
- Lerner, L. S. (2000). *Good science, bad science teaching evolution in the states*. Washington D.C.: National Academy Press.
- Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology*, 18, 205-215.
- Linhart, Y. B. (1997). The teaching of evolution- we need to do better. *BioScience*, 47(6), 385-392.
- Lott, K. (2002, April). *The evaluation of a statewide in-service and outreach program*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, New Orleans.
- The lutheran annual*. (2003). St. Louis: Concordia Publishing House.

- Lutheran Church Missouri Synod. (1922). In W. H. T. Dau (Ed.), *Ebenezer*. St. Louis, MO: Concordia Publishing House.
- Lutheran school statistics 2002-2003*. (2003). Retrieved March 18, 2003, <http://www.lcms.org/graphics/assets/media/DCS/02-03LSSStatistics.pdf>
- MacBain, D. (2003). Towards a just peace: Opening our schools to dissenting world views. *Education Canada*, 43(1), 26-27.
- Matthews, D. (2001). Effect of a curriculum containing creation stories on attitudes about evolution. *The American Biology Teacher*, 63(6), 404-409.
- McKeachie, W. J., Lin, Y.-G., & Strayer, J. (2002). Creationist vs. evolutionary beliefs: Effects on learning biology. *The American Biology Teacher*, 64(3), 189-192.
- McLean v. Arkansas Board of Education, reporter volume first page (529 F. Supp.1255, 50 U.S. Law Week 2412 1982).
- Meadows, L., Doster, E., & Jackson, D. F. (2000). Managing the conflict between evolution and religion. *The American Biology Teacher*, 62(2).
- Meyer, S. C. (1994). Open the debate on life's origins. *Insight on the News*, 10(8), 26-29.
- Miller, K. R. (1994). Life's grand design. *Technology Review*(February/March), 24-32.
- Monsour, T. (1997). Evolution getting short shrift in class. *Saint Paul Pioneer Press*, 149(167), 1, 6.
- Moore, R. (2000a). *In the light of evolution: Science education on trial*. Reston: National Association of Biology Teachers.
- Moore, R. (2000b). The revival of creationism in the United States. *Journal of Biological Education*, 35(1), 17-21.
- Moore, R. (2004). How well do biology teachers understand the legal issues associated with the teaching of evolution? *BioScience*, 54(9), 860-865.
- Moore, R., Mitchell, G., Bally, R., Inglis, M., Day, J., & Jacobs, D. (2002). Undergraduates' understanding of evolution: Ascriptions of agency as a problem for student learning. *Journal of Biological Education*, 36(2), 65-71.
- Morishita, F. (1991). Teaching about controversial issues: Resolving conflict between creationism and evolution through law-related education. *The American Biology Teacher*, 53(2), 91-93.

- National Academy of Sciences. (1998). *Teaching about evolution and the nature of science*. Washington D.C.: National Academy Press.
- National Academy of Sciences. (1999). *Science and creationism* (2nd ed.). Washington D.C.
- National Association of Biology Teachers. (2004). *Statement on teaching evolution*. Retrieved March 5, 2004, http://www.nabt.org/sub/position_statements/evolution.asp
- National Research Council. (1996). *National science education standards*. Washington D.C.: National Academy Press.
- National Science Teachers Association. (1992). *Scope, sequence, and coordination project*. Washington D.C.: NSTA.
- Numbers, R. L. (1982). Creationism in 20th-century America. *Science*, 218(4572), 538-544.
- Oklahoma attorney general issues ruling against evolution disclaimer. (2000). *Church & State*, 53(3), 15.
- Osif, B. A. (1997). Evolution and religious beliefs: A survey of Pennsylvania high school teachers. *The American Biology Teacher*, 59(9), 552-559.
- Ost, D. H. (1995). Risk assessment: Implications for biologic education. *The American Biology Teacher*, 57(3), 140-144.
- Paris, S. G., Yambor, K. M., & Packard, B. W.-L. (1998). Hands-on biology: A museum-school-university partnership for enhancing students' interest in learning in science. *The Elementary School Journal*, 98(3), 267-289.
- Passmore, C., & Stewart, J. (2002). A modeling approach to teaching evolutionary biology in high schools. *Journal of Research in Science Teaching*, 39(3), 185-204.
- Paterson, F. R. A., & Rossow, L. F. (1999). Chained to the devil's throne: Evolution and creation science as a religio-political issue. *The American Biology Teacher*, 61(5), 358-364.
- Peloza v. Capistrano Unified School District (37 F.3d517 (9th Cir., 1994) 1994).
- Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education*, 66(2), 211-227.
- Resolution to commend preaching and teaching creation, 2-08A Lutheran Church Missouri Synod 62 Synodical Convention (2004).

- Robinson, E. (2003). *Kindergarten students' and their parents' perceptions of science environments: Achievement and attitudes*. Curtin University of Technology, Perth.
- Rosen, L. (2003, September 7). Roseville trustees reject a district-wide policy on the teaching of biology. *Sacramento Bee*, p. 1.
- Rudolph, J. L., & Stewart, J. (1998). Evolution and the nature of science: On the historical discord and its implications for education. *Journal of Research in Science Teaching*, 35(10), 1069-1089.
- Russo, E. (2001). Fighting Darwin's battles. *The Scientist*, 15(6), 1.
- Rutledge, M. L., & Mitchell, M. A. (2002). High school biology teachers' knowledge structure, acceptance and teaching of evolution. *The American Biology Teacher*, 64(1), 21-28.
- Rutledge, M. L., & Warden, M. A. (2000). Evolutionary theory, the nature of science and high school biology teachers: Critical relationships. *The American Biology Teacher*, 62(1), 23-31.
- Sandoval, W. A., & Morrison, K. (2003). High school students' ideas about theories and theory change after a biological inquiry unit. *Journal of Research in Science Teaching*, 40(4), 369-392.
- Scharmann, L. C. (1993). Teaching evolution: Designing successful instruction. *The American Biology Teacher*, 55(8), 481-486.
- Scott, E. C. (2000). Not (just) in Kansas anymore. *Science*, 288(5467), 813-815.
- Segraves v. State of California (No. 278978 Sacramento Superior Court 1981).
- Senate Bill No. 394, Tennessee State Senate(1973).
- Sendor, B. (1992). Curriculum supersedes a teacher's beliefs. *The American School Board Journal*, 179, 5-6.
- Shankar, G., & Skoog, G. D. (1993). Emphasis given evolution and creationism by Texas high school biology teachers. *Science Education*, 77(2), 221-233.
- Shaver, C. (2003). The debate over the teaching of evolution in public schools. *Journal of Law & Education*, 34(3), 399-404.
- Singham, M. (2000). The science and religion wars. *Phi Delta Kappan*, 81(6), 424-432.
- Skoog, G. D. (1979). The topic of evolution in secondary school biology textbooks 1900-1977. *Science Education*, 63, 623-625.

- Skoog, G. D., & Bilica, K. L. (2002). The emphasis given to evolution in state science standards: A lever for change in evolution education? *Journal of Research in Science Teaching*.
- Smist, J. (1994, April). *Gender differences in attitude toward science*. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans.
- Smith, M. U. (1994). Counterpoint: Belief, understanding, and the teaching of evolution. *Journal of Research in Science Teaching*, 31(5), 591-597.
- Splitt, D. (1995). Sorting out what is and isn't religious. *The Executive Educator*, 13.
- Support for Kansas board of education's decision to teach evolution. (2001). *BioScience*, 51(2), 163.
- Swarts, F. A., Anderson, O. R., & Swetz, F. J. (1994). Evolution in secondary school biology textbooks of the PRC, the USA, and the latter stages of the USSR. *Journal of Research in Science Teaching*, 31(5), 475-505.
- Tatina, R. (1989). South Dakota high school biology teachers and the teaching of evolution and creationism. *The American Biology Teacher*, 51(5), 275-280.
- Texas Education Code Annual, Title 19 section 81.63 (1974).
- Thomas, D. E. (2000). Science trumps creationism in New Mexico. *Skeptical Inquirer*, 24(1), 5.
- Tyrangiel, J. (2000, July, 10). The science of dissent: A teacher is stirring up trouble about Darwin-- in a very Minnesota way. *Time*, 156, 60.
- Van Koevering, T. E., & Stiehl, R. B. (1989). Evolution, creation, and Wisconsin biology teachers. *The American Biology Teacher*, 51(4), 200-202.
- Veal, W. R., & Kubasko, D. S. (2003). Biology and geology teachers' domain-specific pedagogical content knowledge of evolution. *Journal of Curriculum and Supervision*, 18(4), 334-352.
- Vierra, A., Pollock, J., & Golez, F. (1998). *Reading educational research* (3rd ed.). Upper Saddle River: Merrill.
- Webster's college dictionary*. (1991). New York: Random House.
- Weld, J., & McNew, J. C. (1999). Attitudes toward evolution. *The Science Teacher*, 66(9), 26-31.
- WELS high schools. (2004). Retrieved March 29, 2004, <http://www.wels.net/cps/>
- West Virginia school board supports evolution. (2000). *Church & State*, 53(2), 18.

- White, J. A. R., & Richardson, G. D. (1993, November). *Comparison of science attitudes among middle and junior high school students*. Paper presented at the Annual Meeting of the Mid South Educational Research Association, New Orleans.
- Wilhelm, R. D. (1978). *Chronology and analysis of regulatory actions relating to the teaching of evolution in public schools*. Unpublished Doctoral Dissertation, University of Texas.
- Winterer, J. (2001). Hardy-Weinberg equilibrium and evolution. *The American Biology Teacher*, 63(9), 678-687.
- Wright v. Houston Independent School District, 366 1208 (Texas Federal Court, Houston 1972).
- Zimmerman, M. (1987). The evolution-creation controversy: Opinions of Ohio school biology teachers. *Ohio Journal of Science*, 87(4), 115-125.
- Zook, D. (1995). Confronting the evolution education abyss. *Journal of Research in Science Teaching*, 32(10), 1111-1120.
- Zuzovsky, R. (1994). Conceptualizing a teaching experience on the development of the idea of evolution: An epistemological approach to the education of science teachers. *Journal of Research in Science Teaching*, 31(5), 557-574.

Appendix A

Teaching Evolution Topics Survey

Teaching Evolutionary Topics

This survey has been developed to gather information about teaching evolutionary topics in your biology classes. Your responses will remain confidential and anonymous. Please answer all items on this survey. If you have any questions, please feel free to contact Michael W. Schulteis (michael.schulteis@cui.edu) or Dr. Darrell Fisher (D.Fisher@smec.curtin.edu.au).

Thank you for your time and input on this very important study.

PART 1: EMPHASIS ON EVOLUTIONARY TOPICS

In column A, circle the amount of emphasis that you **CURRENTLY** have given (or will give) to each concept in your biology classroom. In Column B, circle the amount of emphasis you would **CHOOSE** to place on each concept, given unlimited freedom to decide about your curriculum. Please respond to the items based upon biology classes.

1	2	3	4	5
<u>No emphasis</u>	<u>Little emphasis</u>	<u>Some emphasis</u>	<u>Moderate Emphasis</u>	<u>Strong emphasis</u>
I do not emphasize this concept at all	I may mention this concept briefly or informally during the course.	I emphasize this concept in one lesson during the course.	I emphasize this concept in more than one lesson during the course.	I emphasize this concept throughout the course.

Item Note: All items are adapted from the <i>national Science Education Standards</i> (NRC, 1996) and Project 2061 (AAAS 1990, 1993)	COLUMN A How much emphasis do you (or will you) currently give to these concepts during the school year in your Biology class?					COLUMN B Given unlimited freedom, how much emphasis would you choose to give to these concepts in your biology class?				
	1	2	3	4	5	1	2	3	4	5
1 <u>Speciation (overall emphasis)</u>										
A Defining species	1	2	3	4	5	1	2	3	4	5
B Reproductive and geographic isolation	1	2	3	4	5	1	2	3	4	5
C New species evolve from older species	1	2	3	4	5	1	2	3	4	5
2 <u>Diversity (overall emphasis)</u>										
A Diversity as a product of evolution	1	2	3	4	5	1	2	3	4	5
B Classification systems	1	2	3	4	5	1	2	3	4	5
C Adaptation	1	2	3	4	5	1	2	3	4	5

3 <u>Descent with modification (overall emphasis)</u>	1	2	3	4	5	1	2	3	4	5
A Common ancestry between species	1	2	3	4	5	1	2	3	4	5
B Phylogenetic diagrams (tree diagrams), Cladograms	1	2	3	4	5	1	2	3	4	5
C Single-celled ancestor to all living organisms	1	2	3	4	5	1	2	3	4	5
4 <u>Evidence for evolution (overall emphasis)</u>	1	2	3	4	5	1	2	3	4	5
A Fossil evidence	1	2	3	4	5	1	2	3	4	5
B Molecular evidence (DNA, RNA, ribosome)	1	2	3	4	5	1	2	3	4	5
C Anatomic & behavioral evidence	1	2	3	4	5	1	2	3	4	5
5 <u>Natural selection (overall emphasis)</u>	1	2	3	4	5	1	2	3	4	5
A Genetic variation (mutation, recombination)	1	2	3	4	5	1	2	3	4	5
B Environmental selection	1	2	3	4	5	1	2	3	4	5
C Differential reproduction in genetic inheritance	1	2	3	4	5	1	2	3	4	5
6 <u>Pace and rate of evolutionary change (overall emphasis)</u>	1	2	3	4	5	1	2	3	4	5
A Geologic time, earth's age	1	2	3	4	5	1	2	3	4	5
B Evolution does not progress in a set direction	1	2	3	4	5	1	2	3	4	5
C Punctuated equilibrium vs. gradualism.	1	2	3	4	5	1	2	3	4	5
7 <u>Human evolution (overall emphasis)</u>	1	2	3	4	5	1	2	3	4	5
A Common ancestry of human and other primates	1	2	3	4	5	1	2	3	4	5
B Early hominids (Australopithecus, Homo sapiens)	1	2	3	4	5	1	2	3	4	5
C Modern humans evolved recently	1	2	3	4	5	1	2	3	4	5

PART 2: FACTORS INFLUENCING YOUR DECISION

This part of the survey is intended to collect your thoughts on the factors that influence your decisions about teaching evolution. Please answer the questions honestly, as your responses will remain anonymous.

Please use this scale when responding:

SD	D	U	A	SA
Strongly Disagree	Disagree	Undecided or Don't know	Agree	Strongly agree

<u>Item</u>	<u>Response</u>				
8 I am academically well prepared to teach evolution.	SD	D	U	A	SA
9 Evolution is too complex for beginning biology students.	SD	D	U	A	SA
10 Evolutionary topics are supported by scientific evidence.	SD	D	U	A	SA
11 I sometimes substitute the words "change over time" for "evolution" to avoid conflicts.	SD	D	U	A	SA
12 The principal at my school supports teaching about evolutionary topics.	SD	D	U	A	SA
13 The parents at my school agree that students should learn about evolution.	SD	D	U	A	SA
14 My textbook presents sufficient information about evolution.	SD	D	U	A	SA
15 In order to teach evolution comprehensively, I must eliminate other topics from my biology course.	SD	D	U	A	SA
16 I am confident in my ability to teach evolution effectively.	SD	D	U	A	SA
17 My students are interested to learn about evolution.	SD	D	U	A	SA
18 Evolution is a central and unifying theme in biology.	SD	D	U	A	SA
19 I do not teach some concepts, such as human evolution, because they are too controversial.	SD	D	U	A	SA
20 My principal would ask me to de-emphasize evolution in my class if parents protested against it.	SD	D	U	A	SA
21 I have felt pressure from parents in my community to avoid teaching some evolution concepts.	SD	D	U	A	SA
<u>Item</u>	<u>Response</u>				

22	To teach evolution effectively, I must supplement the information in my textbook.	SD	D	U	A	SA
23	I would like to emphasize evolution more, but there is not enough time available to do so.	SD	D	U	A	SA
24	I would like to emphasize evolution more if I had a knowledge of it.	SD	D	U	A	SA
25	All students are capable of understanding evolution.	SD	D	U	A	SA
26	Evolution answers many questions about the natural world.	SD	D	U	A	SA
27	Evolution is a very controversial concept for many people.	SD	D	U	A	SA
28	My principal would agree that all students should learn about evolution.	SD	D	U	A	SA
29	I have had concerned parents question me about the evolution content in my curriculum.	SD	D	U	A	SA
30	The textbook is my primary resource for teaching evolution.	SD	D	U	A	SA
31	The number of topics that I need to teach prevents me from emphasizing evolution more.	SD	D	U	A	SA
32	There are theories other than evolution that better explain the natural world.	SD	D	U	A	SA

PART 3: INFORMATION ABOUT YOU

What grade(s) do you currently teach? _____

How many sections of biology are you currently teaching? _____

For how many years have you been teaching biology? _____

What level(s) of biology do you currently teach? (Mark all that apply)

- | | |
|--|---|
| <input type="checkbox"/> Life science or
Introductory biology | <input type="checkbox"/> AP Biology |
| <input type="checkbox"/> Biology | <input type="checkbox"/> Aquatic science |
| <input type="checkbox"/> Environmental Science | <input type="checkbox"/> Physiology & Anatomy |
| <input type="checkbox"/> other (please indicate): | |

What is your gender?

- ☐ female ☐ male

What is your age?

- | | | | |
|--------------------------------|--------------------------------|--------------------------------|------------------------------|
| <input type="checkbox"/> 21-25 | <input type="checkbox"/> 31-35 | <input type="checkbox"/> 41-45 | <input type="checkbox"/> 50+ |
| <input type="checkbox"/> 26-30 | <input type="checkbox"/> 36-40 | <input type="checkbox"/> 46-50 | |

What is the highest degree that you currently hold?

- | | |
|--|---|
| <input type="checkbox"/> bachelor's degree | <input type="checkbox"/> master's degree |
| <input type="checkbox"/> bachelor's degree plus
hours | <input type="checkbox"/> master's degree plus hours |
| | <input type="checkbox"/> doctoral degree |

Did you graduate from a school in the Concordia University system?

- ☐ yes ☐ no

Approximately how many graduate and undergraduate credit hours of biology have you completed?

- | | | |
|------------------------------|--------------------------------|---------------------------------------|
| <input type="checkbox"/> 0 | <input type="checkbox"/> 6-12 | <input type="checkbox"/> 27-33 |
| <input type="checkbox"/> 1-5 | <input type="checkbox"/> 13-19 | <input type="checkbox"/> more than 33 |
| | <input type="checkbox"/> 20-26 | |

Are you certified to teach biology in your state? ☐ Yes ☐ No

What is the approximate student enrollment at your high school?

- ☐ under 50
- ☐ 50-100
- ☐ 101-200
- ☐ 201-300
- ☐ 301-400
- ☐ 401-500
- ☐ 500-600
- ☐ 600-750
- ☐ more than 750

Which of the following best describes your location?

- ☐ North Eastern United States
- ☐ South Eastern United States
- ☐ North Western United States
- ☐ South Western United States
- ☐ Midwest

Which of the following best describes your community?

- ☐ Rural
- ☐ Urban
- ☐ Suburban

What textbooks do you use in your biology classroom? (Mark all that apply)

- | | |
|---|---|
| <input type="checkbox"/> Biology: Web of Life
(Prentice Hall) | <input type="checkbox"/> Biology: Principles and
Explorations (Holt, Rinehart,
and Winston) |
| <input type="checkbox"/> Biology: The Dynamics of
Life (Glencoe/McGraw-Hill) | <input type="checkbox"/> Holt Biology: Visualizing
Life (Holt, Rinehart, and Winston) |
| <input type="checkbox"/> Fearon's Biology
(Globe Fearon) | <input type="checkbox"/> Biology: The Living Science
(Prentice Hall) |

OTHER (please indicate):

PART 4: COMMENTS (optional)

We invite you to offer any comments. If more space is required, please attach another sheet.

Appendix B

Teacher Survey Cover Letter

October 10, 2003

Greetings,

My name is Michael Schulteis, and I am currently working on a doctoral dissertation study of biology teachers and the emphasis they give to certain topics in biology. I would like to enlist your help as a research subject for this study.

Enclosed is a survey regarding the teaching of evolutionary topics. I am asking that you fill it out as honestly as you can and return it in the provided envelope. All surveys will remain confidential and anonymous. These surveys will help me find out the current condition of emphasis in teaching these particular topics.

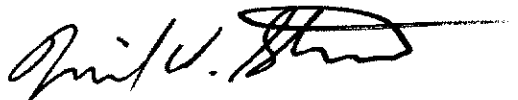
Please answer the questions in all three parts of the survey by writing directly on the survey. Part One deals with how much time you spend teaching about particular topics and how much time you might like to spend. Part Two deals with how you choose what topics to cover. Part Three asks for information about you and the school where you teach. Your participation will help provide an overview of evolutionary topics covered in basic biology classes.

The survey should take between 10-20 minutes of your time. Once you are finished, please return the survey in the provided envelope. Your completion and return of the questionnaire will be taken as evidence of your willingness to participate in this study. Because a high response rate increases the value of this research, your participation in this study is important and appreciated. The target date for completion and return of all the surveys is October 31, 2003.

The purpose of this dissertation survey is to ascertain what is being taught in parochial schools concerning evolutionary topics. The preliminary information attained from you as a front-line teacher will help pinpoint needs which can be addressed in further studies. Without your participation, this study will show a skewed picture of what is being taught in the non-public schools, and will not be effective in furthering excellence in education.

If you would like a copy of the results of this survey, please email me at michael.schulteis@cui.edu.

I thank you for your participation and look forward to receiving your information.



Michael W. Schulteis
Assistant Professor of Education
Concordia University
1530 Concordia West
Irvine, CA 92612
949-854-8002 x1835

Appendix C

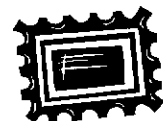
Teacher Survey Follow-up Postcard



You were sent a survey about 3 weeks ago to fill out and I have not yet received yours back yet. I am sending this note as a reminder to fill it out and send it back. It is not too late and I appreciate your taking the time to do this for me.

If your survey has been misplaced or never made it to you please call me at (949) 854-8002 x 1835 or email me at michael.schulteis@cu.edu so I can get another sent out to you right away. If you have already sent your survey, please disregard this postcard.

Michael W. Schulteis
Concordia University
1530 Concordia West
Irvine, CA 92612



Addressee
Lutheran High School
Number, Street
City, State Zip Code

Appendix D

Test of Science Related Attitudes

TOSRA

TEST OF SCIENCE-RELATED ATTITUDES

Barry J. Fraser

DIRECTIONS

- 1 This test contains a number of statements about science. You will be asked what you yourself think about these statements. There are no 'right' or 'wrong' answers. Your opinion is what is wanted.
- 2 All answers should be given on the separate Answer Sheet. Please do not write on this booklet.
- 3 For each statement, draw a circle around
 - SA if you **STRONGLY AGREE** with the statement;
 - A if you **AGREE** with the statement;
 - N if you are **NOT SURE**;
 - D if you **DISAGREE** with the statement;
 - SD if you **STRONGLY DISAGREE** with the statement.

Practice Item

- 0 It would be interesting to learn about boats.
Suppose that you **AGREE** with this statement, then you would circle A on your Answer Sheet, like this:
0 SA **(A)** N D SD
- 4 If you change your mind about an answer, cross it out and circle another one.
- 5 Although some statements in this test are fairly similar to other statements, you are asked to indicate your opinion about all statements.

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Australian Council for Educational Research

Page 2

- 1 Money spent on science is well worth spending.
- 2 Scientists usually like to go to their laboratories when they have a day off.
- 3 I would prefer to find out why something happens by doing an experiment than by being told.
- 4 I enjoy reading about things which disagree with my previous ideas.
- 5 Science lessons are fun.
- 6 I would like to belong to a science club.
- 7 I would dislike being a scientist after I leave school.
- 8 Science is man's worst enemy.
- 9 Scientists are about as fit and healthy as other people.
- 10 Doing experiments is not as good as finding out information from teachers.
- 11 I dislike repeating experiments to check that I get the same results.
- 12 I dislike science lessons.
- 13 I get bored when watching science programs on TV at home.
- 14 When I leave school, I would like to work with people who make discoveries in science.
- 15 Public money spent on science in the last few years has been used wisely.
- 16 Scientists do not have enough time to spend with their families.
- 17 I would prefer to do experiments than to read about them.
- 18 I am curious about the world in which we live.
- 19 School should have more science lessons each week.
- 20 I would like to be given a science book or a piece of scientific equipment as a present.
- 21 I would dislike a job in a science laboratory after I leave school.
- 22 Scientific discoveries are doing more harm than good.
- 23 Scientists like sport as much as other people do.
- 24 I would rather agree with other people than do an experiment to find out for myself.
- 25 Finding out about new things is unimportant.
- 26 Science lessons bore me.
- 27 I dislike reading books about science during my holidays.
- 28 Working in a science laboratory would be an interesting way to earn a living.

Page 3

- 29 The government should spend more money on scientific research.
- 30 Scientists are less friendly than other people.
- 31 I would prefer to do my own experiments than to find out information from a teacher.
- 32 I like to listen to people whose opinions are different from mine.
- 33 Science is one of the most interesting school subjects.
- 34 I would like to do science experiments at home.
- 35 A career in science would be dull and boring.
- 36 Too many laboratories are being built at the expense of the rest of education.
- 37 Scientists can have a normal family life.
- 38 I would rather find out about things by asking an expert than by doing an experiment.
- 39 I find it boring to hear about new ideas.
- 40 Science lessons are a waste of time.
- 41 Talking to friends about science after school would be boring.
- 42 I would like to teach science when I leave school.
- 43 Science helps to make life better.
- 44 Scientists do not care about their working conditions.
- 45 I would rather solve a problem by doing an experiment than be told the answer.
- 46 In science experiments, I like to use new methods which I have not used before.
- 47 I really enjoy going to science lessons.
- 48 I would enjoy having a job in a science laboratory during my school holidays.
- 49 A job as a scientist would be boring.

Page 4

- 50 This country is spending too much money on science.
- 51 Scientists are just as interested in art and music as other people are.
- 52 It is better to ask the teacher the answer than to find it out by doing experiments.
- 53 I am unwilling to change my ideas when evidence shows that the ideas are poor.
- 54 The material covered in science lessons is uninteresting.
- 55 Listening to talk about science on the radio would be boring.
- 56 A job as a scientist would be interesting.
- 57 Science can help to make the world a better place in the future.
- 58 Few scientists are happily married.
- 59 I would prefer to do an experiment on a topic than to read about it in science magazines.
- 60 In science experiments, I report unexpected results as well as expected ones.
- 61 I look forward to science lessons.
- 62 I would enjoy visiting a science museum at the weekend.
- 63 I would dislike becoming a scientist because it needs too much education.
- 64 Money used on scientific projects is wasted.
- 65 If you met a scientist, he would probably look like anyone else you might meet.
- 66 It is better to be told scientific facts than to find them out from experiments.
- 67 I dislike listening to other people's opinions.
- 68 I would enjoy school more if there were no science lessons.
- 69 I dislike reading newspaper articles about science.
- 70 I would like to be a scientist when I leave school.



Test of Science-Related Attitudes

Answer Sheet

Name _____

School _____ Year/Class _____

Page 2						Page 3						Page 4					
	STRONGLY AGREE	AGREE	NOT SURE	DISAGREE	STRONGLY DISAGREE		STRONGLY AGREE	AGREE	NOT SURE	DISAGREE	STRONGLY DISAGREE		STRONGLY AGREE	AGREE	NOT SURE	DISAGREE	STRONGLY DISAGREE
1	SA	A	N	D	SD	29	SA	A	N	D	SD	50	SA	A	N	D	SD
2	SA	A	N	D	SD	30	SA	A	N	D	SD	51	SA	A	N	D	SD
3	SA	A	N	D	SD	31	SA	A	N	D	SD	52	SA	A	N	D	SD
4	SA	A	N	D	SD	32	SA	A	N	D	SD	53	SA	A	N	D	SD
5	SA	A	N	D	SD	33	SA	A	N	D	SD	54	SA	A	N	D	SD
6	SA	A	N	D	SD	34	SA	A	N	D	SD	55	SA	A	N	D	SD
7	SA	A	N	D	SD	35	SA	A	N	D	SD	56	SA	A	N	D	SD
8	SA	A	N	D	SD	36	SA	A	N	D	SD	57	SA	A	N	D	SD
9	SA	A	N	D	SD	37	SA	A	N	D	SD	58	SA	A	N	D	SD
10	SA	A	N	D	SD	38	SA	A	N	D	SD	59	SA	A	N	D	SD
11	SA	A	N	D	SD	39	SA	A	N	D	SD	60	SA	A	N	D	SD
12	SA	A	N	D	SD	40	SA	A	N	D	SD	61	SA	A	N	D	SD
13	SA	A	N	D	SD	41	SA	A	N	D	SD	62	SA	A	N	D	SD
14	SA	A	N	D	SD	42	SA	A	N	D	SD	63	SA	A	N	D	SD
15	SA	A	N	D	SD	43	SA	A	N	D	SD	64	SA	A	N	D	SD
16	SA	A	N	D	SD	44	SA	A	N	D	SD	65	SA	A	N	D	SD
17	SA	A	N	D	SD	45	SA	A	N	D	SD	66	SA	A	N	D	SD
18	SA	A	N	D	SD	46	SA	A	N	D	SD	67	SA	A	N	D	SD
19	SA	A	N	D	SD	47	SA	A	N	D	SD	68	SA	A	N	D	SD
20	SA	A	N	D	SD	48	SA	A	N	D	SD	69	SA	A	N	D	SD
21	SA	A	N	D	SD	49	SA	A	N	D	SD	70	SA	A	N	D	SD
22	SA	A	N	D	SD	<p style="text-align: center;">For Teacher Use Only</p> <p style="text-align: center;">S ____ N ____ I ____ A ____ E ____ L ____ C ____</p>											
23	SA	A	N	D	SD												
24	SA	A	N	D	SD												
25	SA	A	N	D	SD												
26	SA	A	N	D	SD												
27	SA	A	N	D	SD												
28	SA	A	N	D	SD												

Appendix E

Principal Consent to School Participation Letter

December 1, 2003

First Name Last Name
Principal
Lutheran High School
Number, Street.
City, State Zip Code

Greetings,

My name is Michael Schulteis and I am working on my doctorate in science education from Curtin University, Perth, Australia. I am writing to ask for the participation of your biology students in my dissertation research. I have contacted [biology teacher's name] and they have agreed to let me work with their classes assuming you as an administrator will allow me to conduct the research in your school.

My dissertation is on the condition and effects of evolutionary education in the parochial school. I have sent each Lutheran High School Biology teacher in the United States a survey asking about what they teach and how much emphasis they give to evolutionary topics. I also need to "Case study" a group of students if their attitudes toward science change after they have been exposed to teaching about evolutionary topics such as natural selection, classification, rates of change, and the like. This is where I would need your students' help.

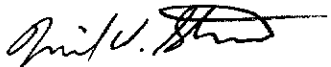
To administer the surveys, I would be at your school two days. The first day I would administer a pre-test survey and the second day a post-test survey. The survey the students will take is called the TOSRA (Test of Science Related Attitudes). It was devised by a couple of my professors at Curtin University where I am working toward my doctorate. It would take between 15 and 30 minutes to administer and the surveys would be kept anonymous with the exception of correlating names from the pre-test to the post-test.

I have also included the parental consent form that would need to be signed if a parent did not want their student to participate in the study.

Would you be willing to let me conduct this research in your school?

You can contact me by replying to this letter by email michael.schulteis@cu.edu or call me at (949)854-8002 xt 1835.

Thank you for your help and I look forward to hearing from you,



Michael W. Schulteis
Assistant Professor of Education
Concordia University, Irvine

Appendix F

Student/Guardian Human Research Subject Consent Form

Consent to Act as a Human Research Subject
Student/Guardian Form

The Condition and Effects of Evolutionary Science Teaching in the Parochial School

Michael W. Schulteis
949-951-3001

Name of Subject (Student): _____

School: _____ Teacher's Name: _____

Purpose of Study: You have been asked to participate in a research project designed to measure the effects of science teaching regarding evolutionary type topics.

Procedures: If you agree to participate in this study, you will be asked to complete two surveys. These surveys will be taken near the beginning of the evolutionary type unit to your biology class and after completion of that unit. **If you would like to abstain from participation in this study please sign and return this form. Not returning this form signifies that you are willing to participate in this study.**

Risks: There are no risks involved in this study, and it will not be a detriment to the classroom or the instruction that is taking place. Student names will be kept anonymous.

Benefits: Results of the research will be shared with you if so desired.

Compensation: No compensation will be given during this study. All responses and answers will be on a volunteer basis only.

Your rights:

1. Participation in research is entirely voluntary. You may refuse to participate or may withdraw from participation at any time without jeopardy to future medical care, employment, student status or other entitlements. The researcher may withdraw you at his professional discretion also.
2. If, during the course of this study, significant new information that has been developed becomes available, which may relate to your willingness to continue to participate, this information will be provided to you by the researcher.
3. Confidentiality will be protected to the extent provided by the law.
4. If at any time you have any questions regarding the research or your participation, you should contact me at the number listed on the top and I must answer all questions you have.
5. If at any time you have comments or complaints relating to the conduct of this research or questions about your rights as a research subject, you should contact the Curtin University Human Research Committee's office at +61 (08) 9266 7863. Human Research Ethics Committee, C/O Office of Research & Development Curtin University of Technology, GPO Box U1987, PERTH, WA 6845

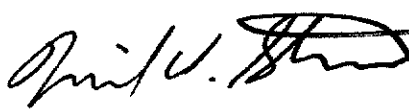
I/We do not want _____ (subject) to participate in this study.

Signature of Subject

Date: ____/____/____

Signature of Parent/Guardian

Signature of Witness



Signature of Researcher

Appendix G

Teaching Evolution Topics Survey Comments

1. I teach biology as theory, not fact since I agree with micro but not macroevolution.

2. Although time is spent at this school teaching evolutionary explanations and origins, this is done in view of 1 peter 3:15-16. "Always be prepared to give an answer to everyone who asks you to give the reason for the hope that you have. But do this with gentleness and respect...." Therefore time is spent with classification systems and the definition of species. A man made system for convenience is stressed. If someone wants to call an organism as a new species, fine. And if it is more convenient to classify dogs and coyotes as different species, fine. Time is spent on the "so-called" fossil evidence, geologic time, punctuated equilibrium and etc. However, the purpose of this is not to prove evolution, but rather teach what evolution says, but more importantly clarify for students that creation stand strong. One does not need to be considered an intellectual weakling while supporting creation. I'm not sure than what the interpretations of my responses will be when I circle 4 (moderate emphasis) for punctuated equilibrium vs. gradualism when the emphasis is not in support of evolution.

3. I teach evolution as change over time. I distinguished between evolution- change over time and the "Theory of Evolution" theory of creation. I teach a decision making model to my Env. Class and teach a 1 week unit on Evolution. Students are presented w/both creation based and evolutionary based theory. Then students use the decision making model and the scientific method to draw a conclusion they are comfortable with.

4. The evolution I teach is information about what is believed and taught by many people. Note the word believed. The observational evidence used to support evolutionary theory can just as well be used to support creation. If your beliefs force you to support evolution. Such bias will prevent an objective view of any evidence. For every "proof" of evolution presented, there exists a sound, supportable response from the Creation perspective. I believe in Creation. It is never my goal to prove creation, I can't, anymore than evolution can be proved. As a matter of fact, anyone who chooses to believe in evolution does a disservice to science and people in general by attacking anyone who believes in creation as being unlearned or foolish. When students complete the biology course in my classroom, they understand the

basic theories of evolution and why people believe them. We learn "how and why" of the theory, without attacking their beliefs. The understanding of how and why people believe in evolution is rooted in a rejection of the creator. Once that is understood, much of evolutionary theory falls into place concerning how and why it was developed. Incidentally, many parts of evolutionary theory that we can witness, (eg. mutations, extinction) fit very well into our daily experiences. Knowing that such events occur does not however constitute proof of larger, unobservable processes such as speciation. Question #18 presupposed the veracity of evolutionary teaching. As such, it is a leading question. In one sense, it very much is a unifying theme, because so much of modern science has sought to make it appear to be unifying. If it is a false theory (and I believe it to be false) then much time and effort are being wasted in pursuit of "proofs" that will never be found. Similarly the numerical or letter responses to other questions (eg. 4,5,23,24) should not be used to artificially infer that the survey shows the teachers believe in evolution. You didn't really ask that question, except indirectly with #32.

5. I feel I have quite a bit of freedom to do as I wish with the biology curriculum that is why in the first section the two columns match up. I do very little with evolution. Plenty of other topics to cover in a limited amount of time. I hope you got a good return and good luck on your program.

6. We teach evolution not as truth, but as another scientific theory that should be tested continually. We hold true that science is a man-made endeavor, and that only God's inerrant Word in the Bible is truth. We believe that God created humans, animals, plants, and all other life with order and with a specific purpose in mind, not that life has come about by chance and that we all wander around this earth with no purpose, but our own personal goals, as is taught in evolution.

7. We do a general survey of evolution in a lecture format during biology class - topic is also briefly covered in Old Testament class with discussion of "the Flood". Students required to do a major research paper on some aspect of evolution with the Christian's response. Evolution is taught as a theory as all theories are covered, but not as a law.

8. I try to give students a firm foundation on the concepts and ideas of Evolution. Many students do not attend a Concordia when they graduate so the science classes they will take center around evolution, so it is important that they have some information. Also in my evolution unit we have an emphasis on Creationism and how creationism is the logical answer based on not entirely, science. I try to get the students to understand through science laws and occurrences that evolution doesn't make logical sense. Disregarding their faith (only briefly) they can see that science doesn't support evolution leaving only one other possibility for the existence of life. Someone must have created it! :)

9. I believe evolution is one of the most unscientific theories to ever appear in a science textbook. I commit many hours studying topics in evolution from a Creationists view point. Biology for Christian Schools does a great job using God's word in Science. I have several great video series- which scientifically show the unscientific basics to evolution. A question I present to every student! Can a person truly be saved if he or she does not believe that God is their creator? Why do we need a savior if we evolved from a single cell? What is scientific about evolution? Evolution can only be accepted by faith! Big Bang? Why are our current cycles working? Water cycle nitrogen cycle All of these topics are fun to use in class I have many more! Our greatest challenge is the dangerous people who try to combine Creation (God) and Evolution! Theistic Evolutionist are very dangerous in [all] of Colleges around the U.S. I would be happy to show my teaching topics with you- Evolution {theories =non-scientific= is a great way to show God at work!

10. I teach in a school where a creation-oriented textbook is used. Evolution is taught as a theory and the flaws along with recent evidence that undermines evolution provided by creation scientists is emphasized. I believe it is important that students are knowledgeable about evolution and be able to clearly and scientifically point out weaknesses in the theory. This is the focus of our teaching here at Lutheran High school.

11. I teach evolution so that the students understand its glaring flaws and see that science supports creationism.

12. I teach a two week unit on evolution and creation we study both sides to all theories. We use lots of journal articles to find what they do here scientific proof for and what is still vague or unexplained. I bring in area pastors and local science professors from the public universities for the kids to ask questions of. Journal articles is my largest source of information

13. I have also taught in the public school system. I was forced to teach evolution as fact since it was on the end of course tests that students took. I disagree with evolution on the basis that it is bad science. I do believe in "microevolution" but not "macroevolution." I teach it as a theory only- not as fact.

14. Regarding column B on the 1st and 2nd page, I feel I have enough freedom to discuss the topics related to evolution in exactly the way I want to: I must state that I believe that the LORD God Almighty created the heavens and the earth and that He created a mature, complex earth. I believe he created human beings in His own image and that we did not evolve from primates. With regard to the teaching of evolution, I feel it is important as Christians, within our faith, to deal with the facts of evolution. Certainly change on our planet, physically and biologically, has occurred and we cannot deny its "evolution." To do so would be ignorant and unreasonable. To the extent that the "facts" should lead anyone to conclude that the earth and everything in it has appeared solely because of "evolution." I would contend that that is a belief based solely on "faith" as well. If we are to prepare students to be faithful and wise stewards of our world, it is important for them to distinguish between what happened and what may have happened; what science is and does and what faith is and does.

15. I teach evolution as a theory and supplement it with material about how parts of evolution are being proved biochemically impossible. I believe it is important for students to learn about evolution in a Christian setting and how to stand up for their creationist beliefs in a non-Christian setting.

16. Evolutionary theory provides a great canvas for students to knock around important developmental concepts and behaviors including: What is truth? How

powerful is God? What is empirical evidence good for? How are theories built and modified. Conflict resolution and listening skills. debate vs. argument

17. Although I teach evolution in my biology course, I do so as a theory. I always stress the Biblical account as a fact. It's important that my students leave with an understanding of evolution, but not at the cost of their souls. Thanks!

18. I do not teach creation science to my students because creation does not fit the criteria for science. I make it clear to my students what I place my faith in and what is just a scientific tool.

19. When I say that I teach things like adaptation, modification and other common evolutionary topics, I present them as "good" science, but I do not present them as truth. Our school is firmly committed to believing in creation and learning about all organisms as incredible creations of God. I use things like speciation and adaptation in terms of microevolution since we do not believe macroevolution occurs.

20. We teach the errors of evolution based on God's word. Science is a study of God's genius.

21. I have taught in a public school for 4 years.

22. We are a Lutheran High School affiliated with the Wisconsin Synod. We don't teach evolution because we believe in creation. When evolution topics come up- especially when we study animals, I tell the kids to know what evolution says, but that we don't have to believe it. I also spend 3/4 of the year on the 11 systems of the human body. I feel getting kids interested in the health/medical related fields will help them best in their lives.

23. My primary focus on evolutionary theory is researched adaptation of organisms to environmental conditions and inferences.

24. Even though presently, I teach very little biology, I have in the past and am most interested in learning from your research project. It's a topic that has concerned me over the years, mainly due to lack of sufficient preparation.

25. As a science teacher in a Lutheran high school, it is my job to tackle controversial issues such as evolution. In the world of secular science, it is not enough for Christians to use "because God said so" as an argument. The students here need to know what "evidence" is out there, and then how to counter those arguments with intelligent responses and scientific information. So, I do teach evolution, but not as fact; it is presented as "change over time" rather than "our ancient ancestors were monkeys."

26. A Concordia University Wisconsin grad, we did not touch the subject of evolution in any depth whatsoever, in the science dept. Any evolution concepts I picked up was from my own personal reading, or a religion class, specifically Old Testament. When teaching from a secular text, I am constantly using the Bible as a guide. This was my first year of teaching where a student has left the school because there was too much God being taught! How sad! What would be nice would be a text that taught both Evolution and Creation.

27. I strongly believe that everyone should be educated about evolution. Many people have such an issue with evolution because they are not educated about it. By presenting the information to the students, they can then make their own educated decisions.

28. I teach my students about the theory of Evolution. I want them to know the basic tenets of the theory to better know the enemy. I am a creationist and so are my students.

29. I teach at a private Lutheran high school in [name of area]. The student demographics of the student body is approximately 1/3 Lutheran, 1/3 Christian, and 1/3 unchurched. The majority of the support, though, comes from the Lutheran parents. Due to the present feelings towards evolution in the Christian church, I choose to cover evolution in a 3-4 period lesson that is primarily discussion driven. I

provide reading material and other information, and allow the students to ask questions and discuss. This is not a tested unit. This is not ideal for me, I would rather include evolutionary issues in every unit. But I do feel that my current strategy is sufficient for the students, and acceptable to the parents.

30. In my school (Wisconsin Evangelical Lutheran Synod), the history teacher teaches about Moslem religion. In religion class, students learn about other denominations (even cults). I teach all students need to know about evolutionary theory. They need to know as much or more than the average student. I teach them that evolutionary theory is the best explanation humans- using their reason- can put forth. It is logical, scientific, and as supported as any theory in any field. The difference is that Christians view the world as created by God. Evolutionary theory is the explanation that works if no faith in God is present. As Paul says in Romans if God doesn't create the world, and man does not sin, there is no damnation, no need for Christ's death on the cross, and no hope for those who live on earth. God is clear to us in His word that he created, sent Jesus to save , and believers- through the Holy Spirit's gift of faith- will receive heavenly eternity.

31. In addition to the topics in the survey, I spend at least on period doing a Bible study so we can discuss creation and the flood. We also spend time discussing how the idea of God as Creator permeates the Old and New Testaments. We discuss the difference between science and religion. We discuss the difference between an evolutionary world view and a Christian worldview. This might affect your understanding of some of my responses. For example, Item 6C I mention punctuated equilibrium and gradualism, but only to illustrate the struggle evolutionists have in agreeing on what the fossil evidence means. In Item 7C I indicated a 1 because I don' t teach that modern humans evolved recently. I don't teach that we've evolved. Many of the other concepts are taught from a perspective of "here's the scientific way of looking at something" then we ask "what evidence supports that idea," "what evidence is lacking," "what assumptions are being made," etc. By the way, I'm not a big fan of scientific creationism, either. Ultimately, you believe in the Bible or you don't, and you believe the evolutionists or you don't. Column A and B nearly match because I am 98% free to design my own curriculum.

32. (Not as much time would be spent on Evolution if I did not teach AP Biology) I find that my students are not always well-equipped to defend their faith when it comes to the creation- evolution issue. They need to have a good basis of understanding of evolution in order to "disprove" it. We look at evolution from all aspects, but the focus is on the process (i.e. adaptation, changes in gene frequencies, environmental influences) not theories. Great conversations come out of our discussions...

33. I do not personally have a strong conviction about evolution. I do feel my students need to understand the theories that are out there. I want them to be informed about ideas they will encounter in college.

34. This survey was difficult to complete because of how people interpret the words used. I am a strong Christian and do not believe in the theory of evolution as a whole. There are some theories that do make sense on a small scale. I do believe students need to know about the theories of evolution, but I do not "teach" it as truth. I would like more time to teach the founding theories of evolution, because students will be bombarded with it in college.

35. In a nutshell- Biology as a course encompasses more "required info" for college and does not allow for a detailed exploration of evolution. Plus Concordia didn't adequately cover the topic in my coursework.

36. In the beginning, God created the heavens and the earth

37. I teach at a Lutheran H.S. I do not cover evolution as an individual unit or as a theme in other units. What I do is every time the topic comes up in the text (which is often) or in the classroom, I use the opportunity to talk about our faith and creation. We do discuss evolution as a theory that is widely accepted in the scientific world, but again that we believe in creation. Column A and B are the same.

38. My answers are the same [in the first section] because I feel I have unlimited freedom

39. It is ironic that I am presently taking "Ecology and Evolution" at a state university. One of my reasons for taking this course is to improve my knowledge of the secular view of evolution, in order to better teach my students the theory of evolution and to prepare them for when they encounter it in the future. I have just begun pursuing a Master's in Curriculum and Instruction but taking my elective courses in biology. Also, I teach the evolutionary topics as a theory not as a fact. I say this because at times your questions seem to ask if I teach as evolution as fact or not.

40. Thanks for the opportunity to respond. Sorry it's late- we received this at the end of our 1st quarter, a hectic time indeed! I teach a unit on evolution, then compare and contrast that with the Bible & Genesis. Then, I compare both to science to show that creation is faith-based, not science-based, and evolution is faith-based, not good-science based. I spend some time using science and science principles to show the problems with the evidences for evolution. I also incorporate other ideas such as Intelligent Design and show the dangers of theistic evolution. Our school tries to prepare our students for science classes that they might be taking at public/private, non-faith based colleges and universities. We want them to be secure in their faith when they are challenged in their future. We want them to understand how true science does not support most evolutionary theories and can be used to dispute natural selection. They are then able to defend their faith and to know that evolution doesn't stand up to the rigors of good science.

41. I teach in college prep. H.S. that prepares teachers and pastors for our church body. We believe in creation.

42. Lutheran High school is affiliated with the Wisconsin Evangelical Lutheran Synod, a conservative Lutheran denomination. All of the faculty and practically the entire student body are members of WELS. We believe that the Bible is God's inerrant word and thus believe in the Biblical account of creation as recorded in the book of Genesis. I intentionally de-emphasize the teaching of evolutionary theory because we don't believe it is true. I do teach some of the rudiments of evolutionary theory so the students have a basic understanding of what many misguided people believe.

43. I have full freedom to choose course content. This is why the first section is all the same.

44. Biology is the study of Life.

45. I teach Evolution as compared to creation. Students need to know both concepts as Christian students.

46. I commend you on your research. I am very excited to see your results and conclusions. In my opinion: that in order to adequately prepare students for the secular world, they have to know the evolutionary model of origins. And, in order to build their faith, students must be educated to the scientific truths of Creation. Understanding both models also puts students in a better position to witness when asked: 1 Peter 3:15. May God Bless your Research.

47. I am given complete freedom to teach evolution. However, I am not given the freedom to teach it as "proven" scientific law. - You need to define "evolution" for this survey. Is it "adaptation"? Is it macro-(evolution), micro-(evolution), etc? - In the Lutheran system, teachers need to be taught better how to teach evolution and the evaluation of the theory, as well as the evaluation of alternative explanations.

48. Without composing a book, which I feel like doing at the time, I echo many statements by the Answers in Genesis staff, Phillip Johnson, Michael Behe, etc. I have spoken at least 3 times on this topic at our state science Teacher's conference (HASTI) and would love to share these truths to our Lutheran Kids at a National Convention! I feel Lutherans as a whole simply rely on the Bible and don't know why evolution is wrong scientifically, philosophically, or theologically! Kudos to you for doing the study and feel free to drop my name to whoever needs speakers on this crucial topic.

49. Often the questions seemed vague. By placing an A or 4 or 5 I felt like I was support "all" evolution teaching. In fact, I do not believe in "one common ancestor" or the totality of "descent with modification," but I do teach those theories. I do

believe in "microevolution" and natural selection. Am I teaching evolution? Is evolution supported by the evidence, then? What does the word evolution mean? I enjoyed filling this out and believe it is well written, but found it difficult to complete. Thanks.

50. I hate teaching evolution/creation! I don't know what I should teach, but I know from the course description that was in place when I got here, along with some comments from parents that they would like to see a bashing of evolution and support of Creation Science. I admit, I don't know much about either. I have been searching for some sort of teacher's guide that teaches concepts of evolution, but with an overall Christian viewpoint and so far have found nothing (Do you know of any?) I have also searched Concordia Publishing House's Web Page in search of books that they support so I can get a better idea of how the LCMS feels about this topic. I am very interested in receiving the results to this survey and any suggestions that you might have on this topic.

51. I have left topics of evolution for last if time permits in the school year. I teach from a creationist view point, but I think knowing both sides of the issue are important in order for Christians to argue against it. Knowing about evolution also helps students understand certain scientific concepts such as taxonomy. I also teach the differences between macro-evolution and micro-evolution.

52. I incorporate some discussion of evolution in my biology classes in order to facilitate academic awareness on the part of my students. I believe this "awareness" is valuable to them as they face our secular world and, I pray, share the Gospel message.

53. This survey does not adequately reflect my philosophical stance on the understanding of the Nature of Science and how I use it as the context for all my teaching, including Evolution, but my answers will suffice the purpose of this is simply to estimate how many teachers are actively teaching about these topics in parochial schools.