"DARWIN'S GREAT IDEA": GEORGIA TEACHERS' EXPERIENCES AND BELIEFS OF THE TEACHING OF EVOLUTION

by

ANGELA SUSAN BROOKS

(Under the Direction of DAVID F. JACKSON)

ABSTRACT

The purpose of this study was to understand teachers' experiences and beliefs of the teaching of evolution within the context of public schooling in Georgia. In support of the purpose of this study, I devised the following research questions: (1) How do teachers describe their preparation for teaching evolution? (2) How do teachers describe their teaching of evolution in secondary school? (3) How do teachers describe the institutional and sociocultural influences that affect teachers' decisions about what and how to teach evolution? Primary data sources were teacher interviews. A purposive sample of secondary biology teachers was recruited. Teacher/participants were recruited from six public school systems in a large metropolitan center in Georgia. Fifteen teachers were interviewed, nine high school teachers and five middle school teachers. These teachers represented eleven schools, and five of the six targeted school systems. The theoretical frameworks that guided this study were interpretivism (Crotty, 1998) and worldview theory (Sire, 2004). Data were coded and analyzed resulting in themes, which provided insight into teachers' preparation for teaching evolution, teachers' pedagogical decisions about how to teach evolution, and institutional and sociocultural influences on

those decisions. Findings included: (1) All teachers in this study were familiar with Georgia evolution standards and their responsibility to teach them. (2) Georgia biology teachers' personal/religious views on evolution vary, and the ways in which those views manifest themselves in teaching evolution vary. Some of the findings from this study match those from studies of teachers in other parts of the United States, while others do not. Among findings that do not match other studies are: (1) Teachers in this study were well prepared with respect to evolution content and pedagogy. (2) Teachers were familiar with content standards on evolution and their responsibility to teach them. (3) Standardized testing was not a significant stressor compared to sociocultural factors such as perceived adverse community viewpoints.

INDEX WORDS: TEACHING, EVOLUTION, GEORGIA, PUBLIC SCHOOLS, INTERVIEWING, INSTITUTIONAL AND SOCIOCULTURAL FACTORS, WORLDVIEW THEORY

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ANGELA SUSAN BROOKS

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ANGELA SUSAN BROOKS

Major Professor:	David F. Jackson
Committee:	Kathleen deMarrais
	Mark A. Farmer
	Julie A. Luft

Electronic Version Approved:

Suzanne Barbour
Dean of the Graduate School
The University of Georgia
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DEDICATION

- To Mary Elizabeth Kelly for her love and support.
- To my parents, Robert and Ruby Brooks, who demonstrated their love for me in so many ways and taught me the importance of hard work to a rewarding life.

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CHAPTER 1

INTRODUCTION

Charles Darwin first published one of the most influential books in the history of science in 1859. Darwin's *The Origin of Species* is now over 150 years old. During that time, the theory of evolution by natural selection has become the unifying theme of biology. Randy Moore, Professor of Biology at the University of Minnesota and well-known education researcher, stated,

> The scientific power of Darwin's great idea shows no signs of fatigue…all biology teachers should be grateful and honored to have jobs that involve helping students and others understand the power and beauty of Darwin's great idea. We are all intellectual descendants of Charles Darwin (Moore, 2009, p. 72).

In spite of Moore's implication that all biology teachers should be teaching an honest and intellectually vigorous version of Darwin's ideas in the study of biology, in the United States today, this goal is not universally accomplished. The aim of this study was to increase understanding of the teaching of evolution among public school teachers in the state of Georgia.

Background of Study

The purpose of this study was to understand teachers' experiences and beliefs concerning teaching evolution within the context of public schooling in the state of Georgia. In this study, the use of the word "belief" implies an orientation or viewpoint

toward evolution, creationism, or some variant of acceptance of the scientific viewpoint of evolution as defined and/or explained by Scott's (2010) continuum of philosophical/religious views toward evolution. Also, in this context, the word "belief" may refer to a teacher's practice concerning what and how evolution should be taught in a public school setting. Those pedagogical practices may be in accordance or at odds with a teacher's religious/philosophical viewpoint.

Previous researchers have identified several factors, which bear on the teaching of evolution. First, acceptance by the scientific community and science educators of the importance of evolution to an understanding of biology is important to the teaching of science. A number of well-respected scientific organizations, including the National Academy of Science (NAS, 1999), National Association of Biology Teachers (NABT, 2000), American Association for the Advancement of Science (AAAS, 2002), and the National Science Teachers Association (NSTA, 2013) support the teaching of evolution in American classrooms.

Secondly, science education standards are based on the scientific community's endorsement of evolution and are important to how pedagogical decisions are implemented. Although there is support for teaching evolution in a scientifically acceptable manner in state standards (Georgia Performance Standards, 2006, 2009) as well as the Next Generation Science Standards (NGSS, 2015), whether or not those supportive standards make a difference to whether or how evolution is taught in Georgia is unclear. Berkman and Plutzer (2010) found some teachers were unaware of the content of state standards on evolution. In addition, these authors found that experienced teachers were more likely to feel immune from being held accountable to state education

standards. Finally, some teachers did not feel threatened enough by high stakes testing of those standards to include evolution in their instruction (Berkman & Plutzer, 2010). Goldston and Kyzer (2009), however, did find evidence that teachers felt constrained to teach evolution because they were accountable for test results, which included questions on evolution. The contradictory connection between standards and what actually gets taught needs further investigation.

Thirdly, according to a number of researchers, legal rulings on evolution are an important influence on teachers and their teaching of evolution (Berkman & Plutzer, 2010; Harris, 2013; Larson, 2006; Moore, 2002; Moore, 2004; Scott, 2009). Legal support for the teaching of evolution may or may not affect individual teachers' pedagogy due to the complex interplay of factors that determine any individual's teaching identity. The teacher has to, at a minimum, be aware of the legal struggle, but understand that teaching evolution has universal legal support in the United States (Moore, 2002; Scott, 2009).

Current literature on teaching of evolution revealed still another theme. Sociocultural factors influence teachers and are enacted through their pedagogical decisions on teaching of evolution (Berkman et al., 2008; Berkman & Plutzer, 2010; Goldston & Kyzer, 2009; Griffith & Brem, 2004; Hermann, 2013; Nye, 2014; Osif, 1997; Rutledge & Mitchell, 2002; Rutledge & Warden, 2000; Tatina, 1989). There are numerous sociocultural reasons evolution may not be taught in public school biology classrooms. If teaching evolution is downplayed, deemphasized, or ignored, the teacher has made a pedagogical decision. First, the teacher's reason for avoidance may be based on her own belief or acceptance of evolution. Secondly, her pedagogical decision could

be based on what she perceives to be her students' belief or acceptance of evolution. Thirdly, her reason could be based on what she perceives to be the broader community's perspective on the teaching of evolution. The broader community could potentially include school or central office administration, the school board, parents, or other stakeholders. Research revealed all of these reasons might play a role, either singly or in combination, in teachers' pedagogical decisions (Berkman et al., 2008; Berkman & Plutzer, 2010; Goldston & Kyzer, 2009; Griffith & Brem, 2004; Hermann, 2013; Van Koevering & Stiehl, 1989; Moore & Kraemer, 2005; Nye, 2014; Osif, 1997; Rutledge & Mitchell, 2002; Rutledge & Warden, 2000; Tatina, 1989).

Statement of the Problem

The theory of evolution is a unifying theme in biology (Dobzhansky, 1973). The National Academy of Science (NAS, 1999), National Association of Biology Teachers (NABT, 2000), American Association for the Advancement of Science (AAAS, 2002), and the National Science Teachers Association (NSTA, 1997) support the teaching of evolution in American classrooms. And yet only 28 percent of teachers "craft lesson plans so that evolution is a theme that unifies disparate topics in biology" (Berkman and Plutzer, 2011, p. 404).

Many teachers in the United States do not teach evolution thoroughly. Researchers have studied this issue and proposed explanations for the discrepancy between the scientific support for teaching evolution and what actually occurs in America's classrooms. Goldston and Kyzer (2009) summarized these reasons as follows: (1) a lack of understanding of the theory of evolution; (2) teachers' perceptions that evolutionary theory conflicts with their own or their students' religious beliefs; (3)

teachers' perceptions that teaching evolution is not accepted in their communities; (4) teachers' rejection of evolution due to deeply held religious beliefs that are not consistent with the teaching of evolution; and (5) teachers' personal choice to teach creationism in their classrooms.

Most Americans believe that teaching evolution should be accompanied by some instruction in an alternate explanation for the origins and diversity of life on Earth such as creationism or intelligent design (Berkman & Plutzer, 2010). A sizeable number of teachers are included in that number (Berkman & Plutzer, 2010). The qualitative research presented here contributes to our understanding of how and why teachers in Georgia do or do not teach evolution.

Purpose of the Study and Research Questions

The purpose of this study was to understand teachers' experiences and beliefs of teaching evolution within the context of public schooling in Georgia. In support of the purpose of this study, I attempted to answer the following questions:

1. How do teachers describe their preparation for teaching evolution?
2. How do teachers describe their teaching of evolution in secondary school?
3. How do teachers describe the institutional and sociocultural influences that affect teachers' decisions about what and how to teach evolution?

Epistemological Considerations and Theoretical Frameworks

The epistemological stance that guided this study was constructionism. According to Crotty (1998, p. 9), a constructionist stance in one is which "meaning is not discovered, but constructed. In this understanding of knowledge,

it is clear that different people may construct meaning in different ways even in relation to the same phenomenon." In this study of the teaching of evolution, I hoped to show how different individuals constructed their teaching in a manner that reflected their idiosyncratic worldviews with regard to evolution.

Crotty also provided a description of the interpretivist stance that formed part of the theoretical framework for this study. Crotty described interpretivism as "attempts to understand and explain human and social reality" (1998, p. 67). Merriam and Tisdale (2015) described the purpose of this perspective is to describe, understand, and interpret. Since this study is an interpretive study, which sought understanding of the participants' experiences and beliefs, the behavior of the participants as described in my interviews with them was used to construct meaning associated with their pedagogy related to the teaching of evolution.

An additional, but related, theoretical framework that I used to help guide analysis in this study was worldview theory. Sire (2004, p. 122) defined worldview as a

> …commitment, a fundamental orientation of the heart, that can be expressed as a story or in a set of presuppositions (assumptions which may be true, partially true or entirely false) which we hold (consciously or subconsciously, consistently or inconsistently) about the basic constitution of reality, and that provides the foundation on which we live and move and have our being.

Our worldview is what is actualized in our behavior. We live our worldview, or it isn't our worldview. This explanation of worldview was important to the study proposed here. This study sought teachers' descriptions of their behavior concerning the teaching of evolution. According to Sire's definition and guidelines for using worldview in analysis, a teacher's behavior is a manifestation of the teacher's worldview. A teacher's worldview may manifest itself in her behavior as Cobern (1996) explained in the difference between comprehension (grasping a concept) and apprehension (taking possession of a concept). Some teachers who have the appropriate content knowledge of evolution may choose not to use that knowledge in their pedagogy because it conflicts with their own or others' perceived worldview with regard to evolution. Therefore, the idea of worldview is particularly relevant to eliciting and interpreting teachers' views on evolution and its teaching.

Overview of Methods

I used interviewing as the primary source of data generation for this interpretive study of teaching evolution in public secondary school science classrooms. According to Bogdan and Biklen (2007, p. 103), an "interview is a purposeful conversation, usually between two people but sometimes involving more, that is directed by one in order to get information from the other." I used a semi-structured interview in this study. Roulston (2010) placed this type of interview on a spectrum between structured and unstructured interviews. Roulston (2010, p. 15) described this type of interview as one in which questions are open ended, although the

> …interviewer follows up with probes seeking further detail and description about what has been said. Although the interview guide provides the same starting point for each semi-structured interview given that it assumes a common set of discussable topics – each interview will vary according to what was said by individual interviewees, and how each interviewer used follow up questions to elicit further description.

A semi-structured interview assumes that individual participants define the world in unique ways. Semi-structured interviews allow the researcher to respond to the situation at hand with some freedom to alter the wording and order of the questions.

Data from this in-depth interview study was analyzed inductively to develop themes. (Roulston, 2010) outlined the following steps of data analysis, which may be productively applied to data generated in interview studies. The thematic approach involved data reduction. The steps included a close reading of interview transcripts, followed by assigning codes to the data in order to define conceptual categories. Sorting and classification of the codes into thematic groupings determined thematic clusters.

The sample for this study was a purposive sample. I investigated teachers' experiences and beliefs of teaching evolution within the context of public schooling in Georgia. My sample was drawn from the population of secondary public school teachers in Georgia. My initial participants came from professional contacts in the Cobb County, Georgia school system and Emory University in Atlanta, Georgia. I expanded my participant pool through a network sample using recommendations from my original participants. I was particularly interested in including diverse perspectives and followed up on leads developed from participants in order to accomplish that objective.

Roulston (2010) used the term ‘quality’ in the sense of demonstrating excellence, but acknowledged that there are many competing terms used in qualitative research. Among these are “validity, reliability, trustworthiness, credibility, transferability and plausibility” (Roulston, 2010, p. 83). Roulston described strategies to assure quality used in qualitative studies generally, and interview studies specifically. Among these were triangulation, neutrality of the interviewer, maintenance of an audit trail, and member checks.

Ethical considerations for conducting research are paramount. This study was submitted to the University of Georgia Institutional Review Board (IRB) for review and permission to proceed before any participants were recruited. Since the participants in this study were teachers, I also submitted IRB requests to the school systems where I expected to recruit teachers. Once school system and UGA permissions were granted, I recruited teachers and scheduled interviews. Informed consent was sought and obtained from all participants. Participants and their schools and school systems were assured of anonymity. Participants were referred to by pseudonym in all quotations. Recordings were made on the researcher’s personal digital audio recorder. Recordings were deleted after transcriptions were completed. One copy of the transcripts will be maintained on the researcher’s personal computer and personal external hard drive for a period of two years after completion of the study. All digital and hard copies of transcriptions will then be destroyed or deleted.

Significance of the Study

Much of the research summarized in the literature review in this study was conducted in states other than Georgia (exceptions are Nye, 2014 and Elgin, 1983). In

addition, much of the research summarized in this study consisted of quantitative studies (Berkman & Plutzer, 2010; Berkman et al., 2008; Elgin, 1983; Van Koevering & Stiehl, 1989; Moore & Kraemer, 2005; Nye, 2014; Osif, 1997; Rutledge & Mitchell, 2002; Rutledge & Warden, 2000; Tatina, 1989). In Hermann's qualitative study (2013) of six biology teachers from Maryland and Illinois, he pointed out that his participants were from two geographical areas that do not have a history of challenging the teaching of evolution and that the views of the teachers may not adequately represent those across the nation. A qualitative study of in-service Georgia public school biology teachers may reveal a rich view of teaching of evolution in a Bible Belt state. The study proposed helped fill this research gap by providing a qualitative study of Georgia teachers' practices and views regarding the teaching of evolution.

CHAPTER TWO

REVIEW OF LITERATURE

Several factors reviewed here bear on the teaching of evolution. First, acceptance by the scientific community of the importance of evolution to an understanding of biology is important to the teaching of science. Secondly, science education standards are based on the scientific community's endorsement of evolution and are important to how pedagogical decisions are implemented. Thirdly, legal rulings on evolution are an important influence on teachers and their teaching of evolution. Finally, sociocultural factors influence teachers and are enacted through their pedagogical decisions on teaching of evolution. Research on these four influences on teachers and their teaching is examined in this section.

Scientific Acceptance of Evolution

A number of well-respected scientific organizations have supported the teaching of evolution as a unifying theme in biology. These include the American Association for the Advancement of Science (AAAS, 2002) and the National Academy of Sciences (NAS, 1999). In their publication Teaching *about Evolution and the Nature of Science* (1998), the National Academy of Sciences (NAS) explained the importance of evolution in the study of biology by pointing out several interrelated factors. Evolution provides a powerful explanation of the similarities of living organisms as well as the diversity of life on Earth. Organisms share many similar kinds of structure and function because of their descent from a common ancestor. On the other hand, evolution also is responsible for the

diversity of life on Earth. Populations of organisms with characteristics enabling them to occupy ecological niches not occupied by other organisms can gradually become so different as to no longer be considered populations, but fully separate species. Over time, species have diversified and occupied more and more ecological niches to allow them to take advantage of new resources. An example of speciation well known to many high school biology teachers occurred in the finches that occupy the Galapagos Islands, made famous by Charles Darwin as a result of his voyage there in 1835 (Weiner, 1994).

In addition to the diversity as well as similarities of living organisms, the very presence of living organisms on Earth over billions of years has altered the physical environment. The composition of our present day atmosphere is due to the presence of living organisms. Organisms that carried out photosynthesis early in Earth's history created an oxygen rich atmosphere. In addition, living communities over time affect weather and the water cycle on Earth. The conclusion of the NAS was "to teach biology without explaining evolution deprives students of a powerful concept that brings great order and coherence to our understanding of life." (NAS, 1998, p. 3).

In addition to providing a logical explanation for similarities and diversity of life, evolution has practical applications. Artificial selection provides an explanation for why organisms become resistant to drugs and pesticides. Artificial selection imposed by humans parallels natural selection in nature. Understanding the impact of artificial selection on the development of domesticated plants and animals from wild organisms can help us develop new food sources. Furthermore, teaching about evolution provides an opportunity for teachers to help students understand the nature of science. Because of the perceived conflict between evolution and some religious beliefs, teaching evolution

provides teachers an opportunity to distinguish between science and other ways of knowing and understanding (NAS, 1998).

Organizations that support and elaborate best practices in science teaching also advocate for the scientific view of evolution in teaching. For example, the National Association of Biology Teachers (NABT, 2011), in its position statement on the teaching of evolution, said,

> Scientists who have carefully evaluated the evidence overwhelmingly support the conclusion that both the principle of evolution itself and its mechanisms best explain what has caused the variety of organisms alive now and in the past. …Teaching biology in an effective, detailed, and scientifically and pedagogically honest manner requires that evolution be a major theme throughout the life science curriculum both in classroom discussions and in laboratory investigations.

The National Science Teachers Association also supports the teaching of evolution in American classrooms. NSTA's (2013) position statement on evolution maintained, "evolution in the broadest sense leads to an understanding that the natural world has a history and that cumulative change through time has occurred and continues to occur." NSTA further stated science textbooks, science curricula, state science standards, and teachers should emphasize evolution "in a manner commensurate with its importance as a unifying concept in science and its overall explanatory power" (NSTA, 2013). Thus, there is evidence both professional organizations of scientists as well as science educators have formally advocated for teaching the view of evolution that is supported by the mainstream scientific community.

Importance of Education Standards

Teaching evolution in public schools has been supported by the inclusion of evolution in state developed science standards for some time. For example, Georgia Performance Standards (GPS) for 7th grade Life Science which were adopted in the summer of 2006 stated, "Students will examine the evolution of living organisms through inherited characteristics that promote survival of organisms and the survival of successive generations of their offspring." Additional elements of that standard stated that students will:

> (a) Explain that physical characteristics of organisms have changed over successive generations;
>
> (b) Describe ways in which species on earth have evolved due to natural selection; and
>
> (c) Trace evidence that the fossil record found in sedimentary rock provides evidence for the long history of changing life forms.

Other closely related standards were those on ecology, including the idea that "changes in environmental conditions can affect the survival of both individuals and entire species." Specifically lacking from the Georgia Performance Standards was any reference to human evolution. However, natural selection, adaptation, common ancestry, and diversity were included.

The state of Georgia also included education standards for high school Biology supporting the teaching of evolution. The high school Georgia Performance Standards (2006) for all science courses were based on AAAS Project 2061's *Benchmarks for Science Literacy* (2009) and were aligned to the National Research Council's *National*

Science Education Standards (1996). Specific to high school Biology in Georgia was the following standard, "Students will evaluate the role of natural selection in the development of the theory of evolution." Additional elements included within this standard were students "will trace the history of the theory of evolution, explain the history of life on Earth, explain how fossil and biochemical evidence support the theory, relate natural selection to changes in organisms, and recognize the role of evolution in pesticide and antibiotic resistance."

Another Georgia high school course in science, Zoology, had standards, which emphasized the teaching of evolution (GPS, 2009). These standards included "place taxa in a phylogenetic (evolutionary) context and provide data to support hypotheses of relationships," and "explain the evolutionary history of animals over the geological history of Earth." Four out of the five content standards for Zoology included evolution as their basis. Mention of human evolution in particular was still missing.

Since Georgia's middle school standards for Life Science and high school performance standards for Biology were published in 2006 and Zoology standards were published in 2009, the National Research Council published *A Framework for K-12 Science Education: Practices, Cross-Cutting Concepts, and Core Ideas* (2012). This document was then used to develop the Next Generation Science Standards (NGSS). The NGSS were written in a collaborative effort, which involved 26 states (including Georgia). Groups such as the American Association for the Advancement of Science (AAAS), the National Research Council (NRC), and the National Science Teachers Association (NSTA) supported this collaboration. The final version of the NGSS was released in April 2013 (NSTA). As of August 2015, fifteen states had officially adopted

the NGSS as their states' science standards. As of the completion of this dissertation, Georgia was not one of the adopting states. The organizations that supported the NGSS encouraged voluntary adoption as a way to standardize guidance in content and practice across grade levels and science disciplines. The NGSS claimed to "establish learning goals in science that will give all students the skills and knowledge they need to be informed citizens, college ready, and prepared for careers" (NSTA, 2014).

The NGSS included three essential dimensions: science and engineering practices, disciplinary core ideas, and crosscutting concepts. One of the core ideas for middle school life science in the NGSS was designated MS-LS4, Biological Evolution: Unity and Diversity. This core idea included the following component ideas: evidence of common ancestry and diversity, natural selection, adaptation, biodiversity, and human evolution. Similar, but more sophisticated, core ideas for evolution and natural selection appeared in the high school biology standards of the NGSS. According to Bybee (2012, p. 17), the evolution concepts in the NGSS had "a long history as the basis for life science in school programs." The teaching of these aspects of evolution certainly was not new.

What does the existence of standards (state or national) have to do with the teaching of evolution? Berkman and Plutzer (2010) investigated the relationship of education standards to the teaching of evolution. These authors maintained that in order to understand this relationship, it was important to understand the role of politicians and policy making to what teachers teach. It was a complex relationship. First, it must be understood that politicians, in the guise of state policy makers, helped decide on the state education content standards. Other stakeholders, such as educators and academics,

contributed to standards as well. These standards, in turn, were the "official policies concerning what students should learn in their public biology classes" (Berkman & Plutzer, 2010, p. 24).

There were a number of influences on the creation followed by implementation of state standards. Berkman and Pluzter (2010, p. 24) identified "principals" as those in a bureaucracy who "write laws and rules subject to electoral constraints – for example, the state policy makers and their appointees who develop standards." Agents, on the other hand, were those who carry out those rules and laws. Teachers were "agents" who operate at the "street level," *i.e.*, in the schools. To further complicate matters, drafting state content standards was political and had a high degree of correspondence with state public opinion. Controversial topics like evolution were especially difficult since evolution was embedded within broader cultural conflicts in American politics. Berkman and Plutzer (2010, p. 96) identified the evolution controversy as an example of a "morality issue" that was capable of eliciting strong public opinions even in the absence of specific scientific understanding of evolution.

Berkman and Plutzer's (2010) investigation of teachers' knowledge of biology content standards demonstrated teachers were not always aware of what they were supposed to be teaching in the classroom. The authors admit they began their study with the assumption that teachers would be familiar with the content standards of the subjects they taught. However, these authors' data suggested there was little consensus among teachers even in the same state about exactly what was included in the standards. Berkman and Plutzer (2010, p. 162) concluded with the question, "If teachers do not

know what is included in the content standards, how can these policies guide their behavior?"

The second of Berkman and Plutzer's (2010) suppositions for the lack of adherence to state standards on evolution by teachers had to do with the difficulty of imposing monitoring and sanctions on teachers who did not comply with teaching the standards. These authors pointed out standardized student testing was the stick that was to enforce the teaching of the standards. However, testing in science alone had never become the high stakes testing that would trigger failure to graduate, failure to be promoted to the next grade, or the imposition of sanctions on a school or school system. It was the test as a whole and not a test of specific standards that was important to whether or not sanctions might be imposed on a school or school system. Particular standards, like those covering evolution and similarly controversial topics (for example, global warming), were subsumed in the overall test outcome.

The results of a qualitative study of three Alabama biology teachers by Goldston and Kyzer (2009), in some respects, contradicted that of Berkman and Plutzer's larger quantitative study (2010). Goldston and Kyzer (2009) found the curricular decisions of the teachers in their study were a result of the expectation that they teach the state biology standards. The standards were tested on the high school graduation exit exam for which the teachers were held accountable. The possibility evolution would be tested on the high stakes exit exam proved sufficient motivation for the teachers in this study to include evolution in their classroom instruction.

A third reason Berkman and Plutzer (2010) suggested to account for whether state standards would be implemented by individual teachers had to do with individual

characteristics of teachers. One of those individual characteristics was experience. Berkman and Plutzer (2010) suggested multiple reasons a teacher with high seniority might not embrace standards. These reasons included investment of time and effort in existing lesson plans, being professionally socialized in a different era, and having tenure, which provided a buffer from administrative pressures. Having a professional identity encouraged teachers to substitute their own judgment for that of policy-making officials. Berkman and Plutzer (2010, p. 170) concluded the "cumulative impact of these findings suggest that state content standards influence the teaching practices of a small subset of teachers." Those teachers who had less than ten years of teaching experience, who believed their state had an assessment test, and who did not rate themselves as exceptional, were the teachers who spent the most time teaching evolution. But those teachers comprised only 20% of the sample in their study. This means that 80% of biology teachers seemed to be immune to state content standards.

In summary, Life Science, Biology, and Zoology standards in Georgia supported teaching evolution in a scientifically acceptable manner, although Georgia standards did not specifically include human evolution. National standards, like the NGSS, also supported the teaching of evolution. Whether or not these supportive standards made a difference in Georgia or elsewhere to whether or how evolution is taught was unclear. Berkman and Plutzer (2010) found that some teachers were unaware of the content of state standards on evolution. They also found some teachers did not feel threatened enough by high stakes testing to include evolution in their instruction. Goldston and Kyzer (2009) found evidence teachers might feel constrained to teach evolution because they were accountable for test results, which included questions on evolution. Finally,

Berkman and Plutzer (2010) found that experienced teachers were more likely to feel immune from being held accountable to state education standards. The contradictory connection between standards and what actually gets taught needs further investigation.

Teaching Evolution: Important Legal Decisions

The teaching of evolution has been an issue in American courts since the Scopes trial and continues to be so to the present day. The legal status of teaching of evolution in the United States began with the so-called Scopes Monkey Trial in Tennessee in 1925 (*The State of Tennessee v. John Thomas Scopes*). John Scopes, a biology teacher in Dayton, Tennessee, was accused of violating Tennessee's Butler Act, which specifically prohibited teaching about human evolution in state funded schools. Scopes was unsure that he had actually taught evolution, but he volunteered to be identified as the defendant in the case. Scopes was found guilty and fined $100, although the verdict was later overturned on a technicality. The case was actually encouraged by local businessmen and politicians to draw publicity to the small town of Dayton. The prosecution in the Scopes trial was represented in part by three-time presidential candidate, William Jennings Bryan, and the defendant's team included Clarence Darrow, a lawyer famous for his leadership in the American Civil Liberties Union. The trial first brought nationwide publicity to the creation-evolution controversy in the United States (Larson, 2006).

The controversy over the teaching of evolution in public schools in the United States has mainly been decided based on judicial interpretations of the First Amendment to the Constitution of the United States. The First Amendment reads,

> Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof; or abridging the freedom of speech, or of the press; or the right of the people peaceably to assemble, and to petition the Government for a redress of grievances.

There are three components to the First Amendment. The Religion Clause states federal law cannot prohibit the free exercise of religion. The Free Speech Clause includes the right to freedom of speech and a free press. The Assembly clause includes the right of the people to assemble peaceably and to petition government for a redress of grievances. All of the legal decisions generated by the controversies regarding the teaching of evolution have been decided based on interpretations of the Religion and Free Speech clauses of the First Amendment (Scott, 2009).

The Religion Clause of the First Amendment has two elements, the Establishment portion and the Free Exercise portion. The combined requirement of the two elements of the Religion Clause is that public institutions, such as schools, have to be religiously neutral. In 1971, the Supreme Court of the U.S. ruled in the case of *Lemon v. Kurtzman* in favor of a three-part test for laws and regulations to determine if they violate the Establishment Clause. *Lemon v. Kurtzman* involved a Pennsylvania statute that provided for state aid to church related elementary and secondary schools in the form of teacher salary supplements, textbooks, and instructional resources. The U.S. Supreme Court decided the Pennsylvania case and that of a similar statute in Rhode Island concurrently. The Supreme Court held that the Pennsylvania and Rhode Island statutes violated the Establishment Clause of the First Amendment to the Constitution. In deciding this case the Supreme Court outlined what was to become known as the three pronged Lemon

Test: (1) Purpose--the statute must have a secular legislative purpose, *i.e*., it cannot have been passed to advance religion; (2) Effect--the statute's effect must be one that neither advances nor inhibits religion; and (3) Entanglement--the statute cannot promote excessive government entanglement with religion. According to Scott (2009, p. 219), "Failure on any of the three prongs of *Lemon* means the bill is unconstitutional. All of the creationism cases decided after 1971 have referred to the *Lemon* test."

The Establishment and Free Exercise portions of the Religion Clause, and the Free Speech clause have all been claimed at various times to either support teaching evolution or to support teaching alternatives to evolution such as creationism or intelligent design. The Establishment Clause (for example, in *Kitzmiller v. Dover* in 2005) has been used to argue against the teaching of intelligent design or creationism because those doctrines have been interpreted as a veiled attempt to encourage a particular religious viewpoint on schoolchildren. The Free Exercise Clause (for example, in *McLean v. Arkansas* in 1982) has been used to argue that teaching evolution is a potential assault on a child's religious belief. This argument has failed in a number of other cases discussed below. The Free Speech Clause has been used to support either the right to present evolution (the *Scopes* trial and *Epperson v. Arkansas*) or, conversely, the right to present creationism (*Webster v. New Lenox*). The Free Speech Clause of the First Amendment has sometimes been used to support "academic freedom," which will also be discussed further below.

The following paragraphs summarize some of the most important United States court decisions that came after the Scopes trial regarding the teaching of evolution. The first five cases were primarily argued using either the Establishment or Free Exercise

portion or both from the Religion Clause of the First Amendment. The final case discussed below (*LeVake v. Independent School District #656*) was argued using the Free Speech Clause of the First Amendment.

Epperson v. Arkansas was tried in Arkansas in 1968. In 1965, Arkansas still had a Scopes era antievolution law on the books. Teacher-plaintiff Susan Epperson sought to legally teach evolution in her high school biology classroom. She argued that the Arkansas law violated her freedom of speech to teach evolution. Originally the law was ruled unconstitutional, but the Arkansas Supreme Court reversed that decision. Upon appeal to the U.S. Supreme Court, the law was ruled unconstitutional. The decision by the U.S. Supreme Court was guided by the following reasoning. The Arkansas law "selects from the body of knowledge a particular segment which it proscribes for the sole reason that it is deemed to conflict with a particular religious doctrine." The First Amendment requires schools to be neutral toward religion. To ban a subject (evolution) because a religious view (fundamentalism) finds it objectionable violates the Establishment Clause of the First Amendment.

In 1982, again in the state of Arkansas, another court challenge to the teaching of evolution occurred in *McLean v. Arkansas*. Arkansas Act 590 proposed "balanced treatment" for evolution and "creation-science." Act 590 proposed that presenting only evolution in schools would create a hostile climate for religious students. The resulting violation of academic freedom was due to indoctrination of students in evolution science alone. Creation science was presented as a strictly scientific view. Plaintiffs included the American Civil Liberties Union and many religious leaders, including Rev. Bill McLean (whose name appears in the citation) of the Presbyterian Church in Arkansas. U.S.

District Court Judge William Overton ruled in favor of the plaintiffs. Judge Overton cited *Lemon v. Kurtzman* as precedent in his decision, and decided that requiring creation science to be taught would promote a sectarian religious view, because creation science was a religious view. Much time was devoted to a general definition of science and how creation science did not meet it. Arkansas did not appeal the U.S. District Court's decision to the U.S. Supreme Court.

In 1987, a case in Louisiana, *Edwards v. Aguillard*, arose from the passage of the Louisiana Equal Time Law, which required equal time for creationism and evolution in public school science classes. Edwin Edwards, at the time, was the governor of Louisiana, and Don Aguillard was a public school biology teacher. The U.S. District Court held that the Louisiana Equal Time Law was unconstitutional because it advanced a religious view due to the requirement that evolution could not be taught unless creationism (a religious view) was taught as well. In other words, evolution could not be taught alone, but only with the accompaniment of creationism. The Louisiana bill was entitled the "Balanced Treatment for Creation-Science and Evolution-Science Act." The Act did not require teaching either creationism or evolution, but did require that if evolutionary science was taught then "creation science" must be taught as well. The stated purpose of the Act was to protect "academic freedom."

The next case using the Religion Clause that is summarized here was *Kitzmiller v. Dover*. In 2005, in Pennsylvania, *Kitzmiller v. Dover* was brought by a group of objecting parents because the Dover School Board instituted a policy in which teachers were required to read a disclaimer about evolution being only a theory and that students should keep an open mind. The school board's policy maintained that the question of the

origin of life is an individual's decision. The intelligent design textbook, *Of Pandas and People*, was offered as a resource for an alternative explanation to the theory of evolution. Judge John Jones of the U.S. District Court ruled against the Dover School District on the grounds that Intelligent Design was a poorly disguised substitute for creationism and therefore, its support by the School District was unconstitutional based on the Establishment portion of the Religion Clause of the First Amendment.

In 2005, a case was brought in Cobb County, Georgia (*Selman v. Cobb County School District*), over evolution being "only a theory." The Cobb County Board of Education ordered stickers to be placed in biology textbooks proclaiming that "evolution is a theory, not a fact" and that the material in the book should be considered with an open mind. A group of parents sued the school board to have the stickers removed. The school board lost, and the stickers were removed. The original Cobb County decision by Judge Clarence Cooper was decided on the basis of the *Lemon* test (specifically the effect prong, as modified by the endorsement test, that a reasonable observer in the community would recognize the ties between criticizing evolution and certain religious views.) The decision was appealed to the Third Circuit Court of Appeals who returned the case to Judge Cooper because they were unable to judge the case on its merits. The plaintiffs were prepared to retry the case, but the defendants settled. There would be no stickers or disclaimers, and the school district was forbidden to remove references to evolution from textbooks (a prior common practice of the Cobb County School System).

At about the same time as the court case *Selman v Cobb County School District* (2005), a controversy over the use of the word "evolution" in the state educational standards arose in Georgia. State Superintendent of Schools, Kathy Cox, removed the

word “evolution” from all Georgia education standards. There was immediate public objection from teachers, scientists, and science educators. Former President Jimmy Carter commented, “As a Christian, a trained engineer and scientist, and a professor at Emory University, I am embarrassed by Superintendent Kathy Cox’s attempt to censor and distort the education of Georgia’s students.” Part of Cox’s response included, “We don’t want the public or our students to get stuck on a word when the curriculum actually includes the most widely accepted theories for biology. Ironically, people have become upset about the exclusion of the word again, without having read the document.” (CNN, 2004). It is possible that Cox’s rationalization of the exclusion of “evolution” (and its replacement with “change over time”) could have influenced Georgia teachers at the time to doubt the scientific acceptance of evolution and to adopt Superintendent Cox’s omission of “evolution” as acceptable practice by science teachers.

The final case summarized here was argued using the Free Speech Clause of the First Amendment. In 1998, a case in Minnesota, *LeVake v. Independent School District #656*, was brought because a Minnesota science teacher felt that his free speech rights were being violated. Rod LeVake was hired to teach biology at Faribault High School. The science department chair and the principal of the high school became concerned about LeVake’s teaching of evolution. When asked about his treatment of evolution in his biology class, LeVake responded that he could not teach evolution as truth, and he believed evolution was impossible (Moore, 2004). LeVake also distributed creationist literature to his colleagues (Moore & Hubert, 2004). He was reassigned to another position, whereupon he sued the school district, claiming that his reassignment was due to his religious views concerning the teaching of evolution. LeVake lost his case based

on the fact that a district is within its rights to specify the curriculum that its teachers should teach. Academic freedom is generally not supported for teachers at the K-12 level. Upon appeal, the Supreme Court, without comment, refused to hear the case.

Knowledge of the legal status of the teaching of evolution could affect how teachers teach (or don't teach) the subject of evolution in their classrooms (Berkman et al., 2008; Berkman & Plutzer, 2010; Scott, 2009). Moore (2004) found that more than 75% of public school teachers in Minnesota knew the following facts: teachers are not required to give equal time to creationism if they teach evolution; teachers do not have to modify their teaching of evolution for students who object because evolution is incompatible with their religious views; tax money can be used to promote teaching of evolution (textbooks, etc.), but not creationism (books, exhibits); the First Amendment does not entitle a science teacher to teach creationism; and a school can force a teacher to teach evolution and stop teaching creationism. Moore (2004) maintained that teachers who know the legal status of evolution can use this knowledge to help keep creationism out of the classroom.

In summary, the teaching of evolution has been an issue in American courts since the Scopes trial in 1925 and continues to be so to the present day. Recent proposals of state statutes in the legislatures of Colorado, Missouri, Montana, and Oklahoma presented challenges to the teaching of evolution in public schools under the guise of academic freedom (Harris, 2013). The legal arguments both for and against the teaching of evolution use primarily the First Amendment to the United States Constitution in which personal liberties of speech and religion are guaranteed. In each case decided in United States courts, the teaching of the scientific basis of evolution by natural selection has

been supported over supernatural interpretations of how the diversity of life on Earth has arisen. These losses in court have not stopped the challenges. Legal support for the teaching of evolution may or may not affect individual teachers' pedagogy due to the complex interplay of factors that determine any individual's teaching identity. The teacher has to, at a minimum, be aware of the legal struggle, but understand that teaching evolution has universal legal support in the United States.

Sociocultural Influences on the Teaching of Evolution

Given the importance of evolution as an organizing framework for explaining the diversity of life on Earth, what evidence is there for whether public school teachers actually teach evolution? In general, research has documented evolution is not universally taught in public high school classrooms (Tatina, 1989; Osif, 1997; Rutledge & Warden, 2000; Rutledge & Mitchell, 2002; Griffith & Brem, 2004; Goldston & Kyzer, 2009; Berkman, et al., 2008; Berkman & Plutzer, 2010; Hermann, 2013; Nye, 2014). This section examines some sociocultural influences that might be responsible for this lack of universality.

There are numerous sociocultural reasons evolution might not be taught in public school biology classrooms. If teaching evolution is downplayed, deemphasized, or ignored, the teacher has made a pedagogical decision. First, the teacher's reason for avoidance might be based on her own belief or acceptance of evolution. This reason seemed to be the most commonly cited, as demonstrated in the paragraphs below. Secondly, her pedagogical decision could be based on what she perceived to be her students' belief or acceptance of evolution. Thirdly, her reason could be based on what she perceived to be the broader community's perspective on the teaching of evolution.

The broader community could potentially include school or central office administration, the school board, parents, or other stakeholders. Research, as outlined below, revealed all of these reasons might play a role, either singly or in combination, in teachers' pedagogical decisions.

The most commonly evident reason evolution might not be taught is the perceived conflict between personal beliefs of the teacher and the concept of evolution. Tatina (1989) surveyed South Dakota high school biology teachers about their attitudes, knowledge, and practices concerning the teaching of evolution. The author mailed a 23-item survey to biology teachers in each of the 200 high schools in South Dakota. Tatina found approximately 73 percent of South Dakota biology teachers included evolution in their classes. Tatina argued evolution was not included in more biology classes because the teachers did not believe it. Tatina maintained teachers couldn't adequately present a topic they did not accept.

Van Koevering and Stiehl (1989) provided biology teachers from Wisconsin public schools an opportunity to characterize their teaching of evolution. Of 146 teachers who responded to a questionnaire, 66% of teachers favored evolution (evolutionists), 30% of teachers committed to promoting either evolution or creation (evolutionary creationists), and 4% favored creation (creationists). Hence, 34% of Wisconsin teachers in this survey had some belief in an alternative explanation to evolution.

Osif (1997) studied evolution and religious beliefs in a survey of Pennsylvania high school teachers. The survey included questions concerning college degrees and years of teaching experience along with questions about religious beliefs. Although 67.7% of teachers in this study agreed that evolution was central to the study of biology,

one-third did not agree. Furthermore, 39% of teachers in this survey felt creationism should be taught. However, it was not clear whether these teachers felt creationism should be given equal time with evolution or taught exclusively. It was also not clear whether the decision to teach creationism was due to the teacher's personal beliefs or those of students or the community.

In a quantitative study of Indiana public high school biology teachers, Rutledge and Warden (2000) attempted to establish the current status of the variables of teacher acceptance of evolutionary theory and their understanding of evolution and the nature of science. These authors found that at least a fifth of the teachers in their study were undecided about or did not accept the scientific validity of evolutionary theory, and this indecision and lack of acceptance was reflected in these respondents' teaching.

Rutledge and Mitchell (2002) conducted a study of Indiana high school biology teachers whose purpose was to explore the conceptions and knowledge structures of evolution held by teachers with varying levels of acceptance of evolutionary theory. The reasoning behind the importance of looking at this association was teachers' attitudes and views about the subject matter they teach influence the structure of their curricular and instructional decisions. This study used a response survey and a concept mapping activity that was mailed to 989 Indiana public high school biology teachers. Rutledge and Mitchell concluded the topic of evolution did not receive appropriate emphasis in high school biology. These authors identified a "non-acceptance group" of teachers who tended to depict evolution as an explanation of low scientific status. This group credited creationism as the definitive explanation of life and its characteristics.

Berkman et al. (2008), in their quantitative study of 939 public high school biology teachers in the U.S., studied the amount of class time spent on evolution. These authors found the majority of biology teachers in their nationally representative survey saw evolution as central and essential to the teaching of biology. However, between 12% and 16% of the nation's biology teachers were creationist in orientation. Data from this study indicated teachers' personal beliefs about evolution had the most influence on the number of hours spent in classroom instruction on evolution. Those teachers who stressed evolution as a unifying theme spent more time on it. Approximately 12% of teachers who spent classroom time on creationism or intelligent design (ID) also indicated that they personally believed creationism or ID was a valid alternative to the Darwinian explanation of speciation.

Scott (2010) delineated a creation/evolution continuum, which included both Christian religious beliefs and philosophical beliefs. I have summarized this continuum in Table 1. From top to bottom of the table, the categories reflect the degree to which the Bible is interpreted as literally true, with the greatest degree of literalism at the top. Religious positions on the continuum are restricted to Christian belief because of the greater influence of conservative Christians in the antievolution movement. According to Scott (2010, p. 63), "antievolutionism in North America is rooted in religiously conservative Christianity." Although viewing beliefs on evolution as a dichotomy may at first seem logical, either accepting evolution or not is nuanced. Groups are more logically viewed as a continuum rather than a dichotomy because of the range of views held by Christians.

Table 1. Religious/Philosophical Beliefs of Christians with Respect to Evolution (from Scott, 2010)

Religious/Philosophical Beliefs	**Definition/Explanation**
Flat Earthism	God created the universe and all life essentially in its current form (special creationism). Flat Earthers believe the Earth is flat and the Bible takes primacy over information provided by science. The Earth is between 6,000 and 10,000 years old. This extreme belief is rare.
Geocentrism	Geocentrists are strict Biblical literalists who believe the Earth is a sphere and is the center of the Universe. They reject modern physics, astronomy, and biology. They believe in special creation of all organisms by God.
Young-Earth Creationism (YEC)	YEC's believe the Earth is between 6,000 and 10,000 years old. They believe in special creation of separate "kinds" of plants and animals, as stated in Genesis. They generally identify with Henry Morris, founder of the Institute for Creation Research.
Gap Creationism	Gap creationism is a type of Old Earth Creationism (allowing that the age of the Earth is ancient). The age of the Earth is accommodated by two separate creation "events" that occurred between verses 1 and 2 of chapter 1 of Genesis in the Bible (Genesis 1:1-2). They believe in special creation of organisms by God.
Day-Age Creationism	Each of the six days of creation in the Bible is interpreted as being much longer periods, thousands or even millions of years. This belief still retains a literal interpretation of Genesis.
Progressive Creationism (PC)	PC's accept the Big Bang as the origin of matter, energy, and time. This belief incorporates only parts of modern biology. God created "kinds" of animals and plants sequentially in accordance with the fossil record.
Intelligent Design Creationism (IDC)	IDC's believe in William Paley's argument that God's existence can be proved by God's works. They accept natural selection but argue it is inadequate for the emergence of major anatomical body types, complex structures like the vertebrate eye, and the origin of life, which require a supernatural creator.

Evolutionary Creationism	Similar to theistic evolutionism, but differs theologically in that God is viewed as being more actively involved in evolution. God the creator uses evolution to bring about the universe according to God's plan.
Theistic Evolutionism	This is a theological view in which God creates through the laws of nature. They accept all the results of modern science including descent with modification. All mainline Protestant seminaries and the Catholic Church teach this brand of evolution.
Agnostic Evolutionism	They accept the view that evolution occurred and doubt the existence of God and whether God acts in the world.
Materialist Evolutionism	They share a high opinion of science and accept evolution. They differ in the degree of belief of God as creator. Three major groups of materialists are agnostics, humanists, and atheists. Atheists reject the existence of God. Agnostic materialists do not believe the question of whether God created can be answered.

This continuum was constructed with the general American population in mind. Since public school teachers in the United States might logically be considered a subset of Americans in general, this continuum might provide a means of determining the range of religious/philosophical viewpoints of teachers in this proposed study.

As mentioned earlier, the decision not to teach evolution might be attributable to other factors than simply the teacher's personal beliefs or acceptance. Griffith and Brem (2004) conducted a study of Arizona biology teachers and their experiences in teaching evolution. Fifteen teachers from the Phoenix, Arizona area were interviewed either one-on-one or in focus groups. Teachers were also asked to respond to surveys. The results of this study led the authors to classify their respondents as "scientists, selective, or conflicted." The selective teachers had a wide range of pedagogical approaches. One of the selective teachers was a creationist who did not teach evolution at all. Another

selective teacher did not allow discussion, used lecture only, and did not even use the word evolution until well into the unit. Conflicted teachers felt stress because they struggled with their own beliefs and worried about the possible impact of their teaching on their students, but felt they must teach evolution.

Moore and Kraemer (2005) compared the responses of Minnesota teachers to similar surveys done in 1994 and 2003. They found the percentage of biology teachers who included evolution in their courses increased from 69% in 1995 to 88% in 2003. They also found biology teachers spent more class hours on evolution in 2003 than they did in 1995. Conversely, they found the percentage of biology teachers who taught creationism increased from 16% in 1995 to 20% in 2003. Teachers who included creationism in their courses also spent more time in 2003 than they did in 1995. Although the increase in the teaching of creationism might represent personal beliefs, teachers also reported pressure to teach creationism from outside sources, primarily parents, administrators, and others (but not school board members).

Goldston and Kyzer (2009) investigated how various social pressures affected teachers and their instruction on the theory of evolution. All three teacher/participants modified their teaching style while covering evolution. Teachers were able to use their autonomy to decide whether to emphasize evolution in their classes. Two of the three teachers studied did emphasize evolution in their classes, but their pedagogy changed to a more cautionary approach compared to other noncontroversial topics that they taught during the school year.

Nye (2014) surveyed Georgia public high school biology teachers for opinions regarding the teaching of creationism and compared the results to a similar survey

conducted in Georgia in 1983. Nye's study revealed that 17% of respondents taught creationism and evolution, 3.4% taught creationism without mention of evolution, and 1.4% of teachers taught neither evolution nor creationism. Although Nye maintained teachers' personal beliefs were major contributors to pedagogical decisions regarding the teaching of evolution and creationism, his data indicated state standards have influenced the teaching of evolution.

Although teachers may feel stresses from a number of sources, they don't always make pedagogical decisions that yield to those sources of influence. Hermann (2013), in an interview study of public high school biology teachers' views on teaching evolution, found a variety of approaches used by teachers to teach evolution. The ultimate aim of his study was to understand the teaching of evolution from the point of view of the teacher. Hermann found that there were a variety of approaches used by teachers to teach evolution. These included avoidance of the topic, advocating for evolution, and neutrality in their presentation. All of the teachers admitted religious beliefs, either their own or what they perceived to be those of their students or community, presented a significant barrier to the teaching of evolution. None of the teachers in this study were willing to alter their pedagogy to try to reduce this barrier.

In their studies, a number of researchers suggested ways to help teachers do a better job of teaching evolution. Strengthening content knowledge and pedagogical content knowledge of science teachers had been suggested by many researchers as a means to help with increasing the percentage of teachers who actually teach the scientifically supported view of evolution (Berkman et al., 2008; Berkman & Plutzer, 2010; Hermann, 2008; Hermann, 2013; Moore, 2004; Griffith & Brem, 2004; Storey,

1997; Smith, 2010; Tatina, 1989; Rutledge & Mitchell, 2002; Rutledge & Warden, 2000; Bandoli, 2008; Moore & Kraemer, 2005). The argument was basically "knowledge is power." However, to a teacher whose philosophical or religious viewpoint is antagonistic to simply more content or pedagogical knowledge, this solution is counter intuitive.

Griffith and Brem (2004) discussed steps that would help make better teachers of evolution through suggestions from the participants in their study. Several participants admitted they lacked confidence in their content knowledge of evolutionary theory. These authors suggested workshops that provide a refresher course might increase teachers' sense of competence and comfort in the classroom. Secondly, some of their participants reported they never had training in the social and personal implications of teaching evolution and how to handle these situations. The authors suggested that teachers would benefit from a safe environment in which to discuss these issues with their colleagues. Thirdly, teachers expressed an interest in lesson plans on evolution that integrated science with social and personal issues. Finally, the negative connotations of evolution especially with respect to legal battles made participants wonder if they were doing something wrong. Obviously, these teachers would benefit from pedagogical responses to these images that would support their advocacy of evolution.

Chapter Summary

Four major influences on the teaching of evolution have been reviewed in this chapter. Prominent scientific professional organizations, such as the AAAS (American Association for the Advancement of Science, 2002) and NAS (National Academy of Sciences, 1999), as well as organizations that support science teaching, such as NABT (National Association of Biology Teachers, 2011) and NSTA (National Science Teachers

Association, 2013), whole heartedly supported the rigorous teaching of evolution in public schools. Education standards at the state level (for example, the Georgia Performance Standards, 2006) and the national level (NGSS, 2013) supported the scientific viewpoint for teaching of evolution. In addition, legal rulings in United States courts have universally supported the scientific viewpoint for the teaching of evolution.

Sociocultural factors influenced the teaching of evolution as well. There were numerous sociocultural reasons evolution might or might not be taught in public school biology classrooms. Although many studies have been done on individual state populations of secondary science teachers, a qualitative study of in-service Georgia teachers has not been done. This represents a significant gap in knowledge that could be addressed in the study proposed here. Why does this study focus on teachers? Teachers have the autonomy to ignore or implement standards, believe or disbelieve the evidence for evolution, and ignore or follow the legal rulings. In addition, sociocultural influences are inescapable. Berkman and Plutzer (2010) believed teachers are at the heart of the battle concerning whether evolution or an alternative non-scientific explanation such as creationism was taught in America's classrooms. These authors (2010, p. 220) found,

> It is the values of individual teachers that most of all determine *de facto* public policy in the nation's public schools. Absent consistent monitoring, strong controls, and sanctions, most teachers are free to teach what they believe is best, constrained only by their desire to avoid controversy. The result is an enormous variety of teaching approaches to evolution even when teachers are supposed to be guided by the same standards and assessment tests.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

The purpose of this study was to understand teachers' experiences and beliefs of teaching evolution within the context of public schooling in Georgia. In support of the purpose of this study, I answered the following questions:

1. How do teachers describe their preparation for teaching evolution?
2. How do teachers describe their teaching of evolution in secondary school?
3. How do teachers describe the institutional and sociocultural influences that affect teachers' decisions about what and how to teach evolution?

This chapter includes the theoretical framework that guided the analysis of the research, a description of the research design and rationale for the study, data collection methods, data analysis, participant selection, methods for quality assurance, and ethical considerations.

Epistemological Considerations and Theoretical Frameworks

The theory of knowledge or epistemological stance that guided this study was constructionism. Constructionism is a common epistemology invoked by qualitative researchers. According to Crotty (1998, p. 9), a constructionist stance is one in which "meaning is not discovered, but constructed. In this understanding of knowledge, it is clear that different people may construct meaning in different ways, even in relation to the same phenomenon." In this

study of the teaching of evolution, I hoped to show how different individuals constructed their teaching in a manner that reflected their idiosyncratic worldviews with regard to evolution.

Crotty (1998) provided a description of the interpretivist stance that formed part of the theoretical framework for this study. Crotty described interpretivism as "attempts to understand and explain human and social reality" (1998, p. 67). Merriam and Tisdell (2015, p. 9) explained the connection between constructionism and interpretivism in the following manner,

> Interpretive research, which is the most common type of qualitative research, assumes that reality is socially constructed: that is, there is no single, observable reality. Rather, there are multiple realities, or interpretations, of a single event. Researchers do not 'find' knowledge; they construct it.

Merriam and Tisdale (2015) described the purpose of this perspective is to describe, understand, and interpret. Since this study is an interpretive study, which sought understanding of the participants' experiences and beliefs, the behavior of the participants as described in my interviews with them was used to construct meaning associated with their pedagogy related to the teaching of evolution.

An additional, but related, theoretical framework that I used to help guide analysis in this study was worldview theory. What follows is a general definition of worldview theory, followed by a discussion of worldview theory as it applies to science and science education. Sire (2004, p. 122) defined worldview as a

> …commitment, a fundamental orientation of the heart, that can be expressed as a story or in a set of presuppositions (assumptions which may be true, partially true or entirely false) which we hold (consciously or subconsciously, consistently or inconsistently) about the basic constitution of reality, and that provides the foundation on which we live and move and have our being.

Sire provided the following elaboration of the language of the definition. He explained "fundamental orientation*"* as coming from a region not normally accessed by the conscious mind (2004, p. 124). He broadly defined his conception of "heart" as "the central defining element of the human person" (2004, p. 124). Sire explained this fundamental orientation emerges because we normally "think *with* our worldview and *because* of our worldview, not *about* our worldview" (2004, p. 124). Sire noted although worldview is not a story or a set of presuppositions, it may be expressed that way. Sire maintained our worldviews provide the foundation on which we live. Our worldview is what is actualized in our behavior. We live our worldview, or it isn't our worldview. However, what we actually hold about the nature of fundamental reality may not be what we say. Sire (2004, p. 135) provided the following guidelines for using this concept in analysis.

> The explicit presuppositions of anyone's worldview may not change, but their lived-out character will be emphasized. Whether we are looking at our own worldview, that of another person, or

> that of a whole society, age or culture, our attention will be drawn to the behavioral dimension.

This explanation of worldview was important to this study. I sought teachers' descriptions of their behavior toward the teaching of evolution. According to Sire's definition and guidelines for using worldview in analysis, a teacher's behavior is a manifestation of the teacher's worldview.

What is the connection between worldview and science? Gauch (2009) wrote the introductory and concluding essay in a special issue of the journal *Science & Education* on science, worldviews, and education. In his introductory essay, Gauch discussed the seven "pillars" of science. These pillars were realism, presuppositions, evidence, logic, limits, universality, and worldview. These pillars, as defined by Gauch (2009), have the following meanings (Gauch, 2009, p. 674). "Realism" simply means the physical world we occupy is real. The "presuppositions" of science are that the world is orderly and comprehensible. Science demands "evidence," such as observations of phenomena, for its conclusions. Scientists must use standard "logic" in forming conclusions. Science has "limits" in its understanding of the world. Many matters cannot be usefully examined in a scientific way. "Universality" means science is public and open to multicultural perspectives. Lastly, science should contribute to a meaningful "worldview."

Although these ideas might seem platitudinous, Gauch (2009) maintained they were very powerful upon an examination of their implications. Gauch argued based on these pillars, although "the presuppositions and reasoning of

science can and should be worldview independent, empirical and public evidence from the sciences and humanities can support conclusions that are worldview distinctive" (2009, p. 667). Furthermore, Gauch concluded that "worldview-distinctive conclusions based on empirical evidence are suitable for individual convictions and public discussions, but not for institutional endorsements and scientific literacy requirements" (2009, p. 667).

> Cobern (2000, p. 237) explained worldview theory as being
>
> …composed of those fundamental ideas that one simply takes for granted because they are culturally learned and supported, and have been found through daily experience to be viable. On a daily basis people operate on presumption giving little thought to fundamental ideas until placed in a situation where those ideas are explicitly called into question.

Cobern (1996) further explained that a worldview is the set of fundamental nonrational presuppositions on which these conceptions of reality are grounded. Cobern argued it is no use trying to see behind these worldview presuppositions except in the sense of trying to understand the sociocultural environment that leads to a worldview. The teaching of evolution is a situation that may call into question fundamental presumptions some teachers may have regarding scientific and religious ideas they may personally hold or that are held by their constituents (students, parents, administrators, community members). Sociocultural environmental influences have been examined in several studies of the teaching of evolution (Goldston & Kyzer, 2009; Griffith & Brem, 2004).

Cobern (1996, p. 580) explained how the ideas of "force" and "scope" are important to an understanding of worldview theory. A concept or belief has force if it is

central in an individual's thinking rather than marginal. A concept or belief has scope if it has relevance for the individual over a wide range of contexts. For example, Griffith and Brem (2004) identified one group of biology teachers as "conflicted." These were teachers who struggled with their own beliefs and the possible impact of those beliefs on their teaching. For these teachers, the conflict arose from the "force" or centrality their personal views about the validity of evolution had for them. Two of the teachers that Goldston and Kyzer (2009) studied were less willing to teach human evolution than the evolution of lower life forms because their students tended to view humans as special creations of God. The "force" and "scope" of their own or their students' religious beliefs affected these teachers' practice.

Cobern (1996) maintained the difference between comprehension and apprehension may further explain how worldview influences teaching. Cobern (1996, p. 592) stated, "comprehension (grasping a concept) does not necessitate apprehension (taking possession of a concept). One may well reject a concept that he or she fully comprehends while someone else apprehends it as knowledge." This aspect of worldview may be operating with teachers who have the appropriate content knowledge of evolution, but choose not to use that knowledge in their pedagogy because it conflicts with their own or others' perceived worldview with regard to evolution. Berkman and Plutzer (2010) found that personal beliefs not only influence instruction, but also have a stronger impact than any other factor they examined, including number of credit hours in biology, possession of a science degree, certification, and seniority, among others. In a study of Indiana public high school biology teachers, Rutledge and Warden (2000) found teacher acceptance of evolutionary theory was low, but so was their academic

understanding of evolution. This non-acceptance might be seen as arising from the worldview of these teachers. Worldview theory might be productively used as a framework in which to examine teachers' views and practices in teaching evolution.

Anderson (2007, p. 664) maintained teaching the theory of evolution needs to be understood in "its social, intellectual, and pedagogical context—a context that is multifaceted, complex, and influential." Students' individual worldviews, which are greatly influenced by their religious beliefs, might be responsible for the fact they enter the classroom skeptical about evolution. Anderson described the ways in which religious worldviews and science relate. He summarized these relationships (using a classification scheme attributed to Barbour, 2000) as:

1) Conflict – the scientific view of evolution and a religious worldview are diametrically opposed with no hope of reconciliation.

2) Independence – religion and evolution are not in conflict, but represent different endeavors; science deals with the "how" questions and religion with the "why" questions.

3) Dialogue – conversation between scientists and theologians may have benefits, with a mutual understanding of the limits of each endeavor.

4) Integration – a closer partnership between scientists and theologians could result in a possible integration of science and religion.

These four positions may provide a helpful classification system for a teacher's approach to teaching evolution.

In summary, the components of worldview theory presented here include, in part, how foundational presuppositions ground reality, how sociocultural influences affect our

worldview presuppositions, and how force and scope determine the extent to which our presuppositions influence our behavior in acting out our worldview. These ideas served as a useful framework to help understand how individual teachers' views and practices varied in teaching evolution in public school classrooms in Georgia.

Data Collection

I used interviewing as the primary source of data generation for this interpretive study of teaching evolution in public secondary school science classrooms in Georgia. According to Bogdan and Biklen (2007, p. 103), an "interview is a purposeful conversation, usually between two people but sometimes involving more, that is directed by one in order to get information from the other." I used a semi-structured interview in this study. Roulston (2010) placed this type of interview on a spectrum between structured and unstructured interviews. Roulston (2010, p. 15) described this type of interview as one in which questions are open ended, although the

> …interviewer follows up with probes seeking further detail and description about what has been said. Although the interview guide provides the same starting point for each semi-structured interview given that it assumes a common set of discussable topics – each interview will vary according to what was said by individual interviewees, and how each interviewer used follow up questions to elicit further description.

A semi-structured interview assumes individual participants define the world in unique ways. Semi-structured interviews allow the researcher to respond to the situation at hand with some freedom to alter the wording and order of the questions. It is the fluid

nature of the semi-structured interview, which allowed me the freedom to pursue turns of conversation while staying within the bounds of the research questions.

Structured interviews are often used in quantitative studies, while unstructured interviews proceed with no interview guide. Since this was not a quantitative study, structured interviews would not have served my purpose. Unstructured interviews would have required an unwarranted investment in time for an inexperienced qualitative researcher like myself.

Since I was interested in finding out what teachers do and how they respond to teaching evolution in their classrooms, I used interviews to reconstruct their experiences as nearly as possible without actually being in the classroom with the teacher. The following quote from deMarrais (p. 59, 2004) described precisely what I attempted to accomplish:

> Qualitative interviews are used when researchers want to gain in-depth knowledge from participants about particular phenomena, experiences, or sets of experiences. Using interview questions and follow-up questions, or probes, based on what the participant has already described, the goal is to construct as complete a picture as possible from the words and experiences of the participant. This can only be accomplished when the qualitative interview is open ended enough for the participant to provide a depth of knowledge on the research topic. The intent is to discover that person's view of an experience or phenomenon of study.

In support of this goal, I used the interview guide in Table 2 for this study.

Table 2: Interview Guide

Research Questions	Interview Questions
1. How do teachers describe their preparation for teaching evolution?	1. Tell me about your preparation for teaching evolution. PROBES AFTER INITIAL QUESTION: -in your teacher education program? -other professional development you have participated in? 2. How has your preparation supported your ability to teach evolution (how or how not)?
2. How do teachers describe their teaching of evolution in secondary school?	1. Think about a time when you taught evolution and tell me about it. (then ask for another time, and another) PROBES: --How do you teach evolution concepts in your classroom? ---What are some of the general lesson plans, activities, texts, labs, or other resources that you use to teach evolution? ---How do you think your lessons on evolution went? --Tell me about challenges you've had in teaching evolution. --How have you dealt with those challenges?
3. How do teachers describe the institutional and sociocultural influences affect teachers' decisions about what and how to teach evolution?	1 How do you think the larger community here views evolution? 2. How do you think the school community (your colleagues, administration, students) view evolution? 3. What are your personal views on evolution?

Data Analysis

Data from this in-depth interview study was analyzed inductively to develop themes. Roulston (2010) outlined the following steps of data analysis, which were productively applied to data generated in this interview study. This thematic approach involved data reduction. The steps included a close reading of interview transcripts, followed by assigning codes to the data in order to define conceptual categories. Sorting and classification of the codes into thematic groupings determined thematic clusters. Finally, reorganization of the data into thematic representations of findings was accomplished through a series of assertions and interpretations. These themes were supported by evidence from the data set in the form of excerpts from interviews linking the researcher's assertions to what was said by speakers in interview contexts. Although coding and categorization were explained by Roulston as separate steps, "they are likely to be undertaken concurrently, as these processes inform each other" (2010, p. 154).

Wolcott (1994) advised incorporating description, analysis, and interpretation for thematic analysis. I also incorporated Wolcott's ideas in my analysis. Description was the most basic level and involved a narrative presentation of the study's data. Description answered the question of 'what is going on here?' The second level, analysis, was driven by the construction of categories or themes that were drawn from the preponderance of the data. Categories described the data, but also provided some interpretation of the data. Categories were linked in a meaningful way. In this study, the categories were linked with the study's purpose of understanding teachers' experiences and beliefs of teaching evolution within the context of public schooling in Georgia. Analysis focused on essential features and interrelationships. Interpretation went beyond

the generated data to explore meanings, or in Wolcott's words, "What is to be made of it all?" (1994, p. 12).

I used worldview theory to interpret the meaning of the interview data generated in this interpretive study, particularly with respect to teachers' personal philosophical or religious viewpoints on evolution. I was specifically interested in finding how teachers' views of teaching evolution operate in light of force (how central the concept of evolution was to the teachers' worldview) and scope (how relevant the concept of evolution was to the teachers' worldview). Data generated in this study was used to further understanding of how teachers taught evolution in Georgia, as well as what challenges they experienced and the ways in which teachers met those challenges.

Participant Selection

The sample for this study was a purposive sample. I investigated teachers' experiences and beliefs of teaching evolution within the context of public schooling in Georgia. Upon obtaining Institutional Review Board (IRB) approval from the University of Georgia, I submitted IRB requests to six school systems in a large metropolitan center in Georgia. My IRB requests to those six school systems were subsequently approved. My sample was drawn from the population of secondary public school science teachers in five of these six public school systems. Fifteen teachers were interviewed, nine high school teachers and five middle school teachers. These teachers represented 11 schools and 5 school systems. They are identified by pseudonym in Table 2 according to the school and system where they taught.

Participants were recruited through a professional contact at Emory University's Center for Science Education (Atlanta, GA) and a long time biology teacher in Cobb

County, Georgia. In addition to these two primary sources of participants, I expanded my prospective participant pool through a network sample using recommendations from my original participants. I was particularly interested in including diverse perspectives in terms or philosophical and religious worldviews. I believe I accomplished that objective as will be evident in the data analysis that follows this chapter.

Quality Assurance

Roulston (2010) used the term 'quality' in the sense of demonstrating excellence, but acknowledged that there are many competing terms used in qualitative research. Among these are "validity, reliability, trustworthiness, credibility, transferability and plausibility" (Roulston, 2010, p. 83). Roulston also suggested some strategies to assure quality used in qualitative studies generally, and interview studies specifically. Among these are triangulation, neutrality of the interviewer, maintenance of an audit trail, and member checks.

Mathison (1988, p. 13) maintained, "triangulation is typically perceived to be a strategy for improving the validity of research or evaluation findings." I used data triangulation in which multiple sources of data about a phenomenon are sought across groups of people, settings, and place. I was able to accomplish this by recruiting participants from different school systems, different grade levels, and different educational backgrounds. For example, I was struck by the number of teachers across grade levels and schools who used similar activities, like a bird beak adaptations lab, in their teaching of evolution. Another strategy I employed was adequate time spent collecting data. Merriam (2002, p. 31) suggested this might involve seeking discrepant or negative cases of the phenomenon under investigation. In the case of this study, there

were teachers who were not challenged by teaching evolution, and others for whom teaching evolution was a stressful experience for a variety of reasons. I was interested in seeking out teachers who represented diverse perspectives in teaching evolution, for personal and professional reasons.

Roulston (2010) suggested neutrality of the interviewer as a hallmark of quality. The researcher should construct detailed subjectivity statements that outline the subject positions occupied by the researcher prior to and during the study. Roulston (2010, p. 87) maintained:

> The bias of the researcher is addressed by asking questions that do not lead the interviewee; open-ended questions are asked in particular sequences, usually from general to specific, with sensitive topics approached at a later stage in the interview after sufficient rapport has been developed between the interviewer and interviewee.

The interview guide for this study met Roulston's (2010) criteria. Questions range from general to specific, with most sensitive questions (personal beliefs of the participant) at the end.

Researchers should systematically identify their subjectivity throughout the course of their research. Subjectivity is the "amalgam of the persuasions that stem from the circumstances of one's class, statuses, and values interacting with the particulars of one's object of investigation" (Peshkin, 1988, p. 17). Peshkin advocated for an awareness that results from a formal, systematic monitoring of self, "not retrospectively when the data have been collected and the analysis is complete, but while their research is actively in progress" (Peshkin, 1988, p. 17).

My plan involved monitoring my subjective self as a veteran science teacher who has a strong content area background in biology and advocates for the scientific view of evolution as the explanation for the diversity of life on Earth. For me, one of the traps of interviewing was asking leading questions. Several times during the interviews I conducted, I stopped in mid-question because I realized I was asking questions in such a way as to lead into a particular response. My teacher/scientist identity got in the way of my researcher identity. This tendency diminished as I became more experienced at conducting interviews.

Most of my participants were strangers to me. These participants did not know me well enough to make assumptions about my teaching identity. I discovered one of my strengths as an interviewer was establishing rapport with both acquaintances and strangers. Roulston (2010, p. 87) suggested establishing rapport as beneficial in getting the information the researcher seeks. I think I was able to do that in this study.

I created an audit trail. According to Merriam (2002, p. 27), an "audit trail in a qualitative study describes in detail how data were collected, how categories were derived, and how decisions were made throughout the inquiry." I used Atlas.ti, a qualitative data analysis software program. I also recorded audio memos on problems that arose during data collection. Roulston (2010, p. 87) asserted the audit trail would make the research process transparent to readers by "documenting it in a detailed way that may be replicated by others."

There are other means of assuring trustworthiness of data analysis. One of these is to include member checks. I asked my participants to review transcripts of their

interviews and to offer their feedback on accuracy and interpretation. None of my participants chose to do this. Roulston (2010) suggested that the researcher may want to ask interviewees to assess and add to the preliminary findings developed by the researcher in a follow-up meeting or interview, or provide copies of preliminary reports and manuscripts for the participants to comment on. None of the participants in this study chose to offer feedback in a follow-up interview or from preliminary findings.

Ethical Considerations

Ethical considerations for conducting research are paramount. This study was submitted to the University of Georgia Institutional Review Board (IRB) for review and permission to proceed before any participants were recruited. IRB applications were also submitted to six school systems for permission to conduct the study. In addition, individual school principals were asked to provide consent to conduct the study in their schools. Informed consent was solicited from all participants. Participants and their schools and school systems were assured of anonymity. Participants are referred to by pseudonyms in this report. Recordings were made on the researcher's personal digital audio recorder. Recordings were deleted after transcriptions were completed. One copy of the transcripts will be maintained on the researcher's personal computer and personal external hard drive for a period of two years after completion of the study. All transcriptions and hard copies will then be destroyed or deleted.

Chapter Summary

In this chapter, I included a discussion of the purpose and research questions that guided this study. This chapter also included the theoretical framework that guided the analysis of the data, a description of the research

design and rationale for the study, data collection methods, data analysis, participant selection, methods of quality assurance, and ethical considerations.

CHAPTER 4

FINDINGS AND ANALYSIS

Research questions for this study guided the collection, presentation, and analysis of data presented in this chapter. Research questions were: (1) How do teachers describe their preparation for teaching evolution? (2) How do teachers describe their teaching of evolution in secondary schools? (3) How do teachers describe the institutional and sociocultural influences that affect teachers' decisions about what and how to teach evolution?

Findings in this study were gleaned from interviews of fifteen Georgia science teachers conducted in April, May, and June of 2015 by the author. Since these 15 teachers were public school teachers in the state of Georgia, their classes were governed by educational standards defined primarily by the Georgia Performance Standards (2006, 2009). Nine of the fifteen teachers were high school teachers. High school teachers in this study taught subjects as diverse as biology, AP (Advanced Placement) and IB (International Baccalaureate) biology, environmental science, AP environmental science, human anatomy and physiology, and zoology. Each high school course had a unique set of Georgia Performance Standards. AP and IB programs imposed additional requirements on high school courses. Five of the teachers taught life science, which also had its own set of Georgia Performance Standards, to 7th grade middle school students.

The remainder of this chapter includes narrative sketches of the fifteen Georgia teachers who participated in this study, followed by specific findings related to the

research questions that guided the purpose of this study. These findings were derived from coding the data and determining themes from interviews with the teacher participants.

Teacher Portraits

In the following teacher portraits, findings that are most relevant to the research questions of this study are presented in a narrative format. High school teachers' narratives are presented first, followed by middle school teachers, in the order in which they are listed in Table 3. Teachers as well as school names are referenced by pseudonym only. Table 3 contains a master list of teachers, schools, and school systems by pseudonym. All school systems are located in a geographic area of Georgia surrounding a large urban center. The school systems more centrally located in that urban center are classified as urban school systems. The school systems more peripherally located with respect to the large urban center are classified as suburban school systems. There are a total of 5 school systems, 11 schools, and 15 teachers represented in this study.

Table 3: Teacher, School, and School System Pseudonyms

Teacher Name	High School Names	School System
June	East Broad High School	Suburban System A
Garrett	East Broad High School	Suburban System A
Barbara	Spruill High School	Suburban System A
Lily	Madison River High School	Suburban System A
Mary	Madison River High School	Suburban System A
Catherine	Cannon High School	Suburban System B
Molly	Stephens High School	Urban System A
Virginia	Stephens High School	Urban System A
Tracey	Woodland High School	Urban System B
Terrie	Susan B. Anthony High School	Urban System B
Teacher Name	**Middle School Names**	**School System**
Carey	Henry Middle School	Urban System A
Keelin	Henry Middle School	Urban System A
Joseph	Stark Middle School	Urban System B
Ulpa	Greene Middle School	Urban System B
Lisa	Morgan Middle School	Urban System C

June

During June's time as a teacher at East Broad High School, she taught Zoology, Human Anatomy and Physiology, and Biology. At the time of our interview, she had been teaching nine years, seven of which were in high school and two years in 7th grade

(middle school) Life Science. Although her undergraduate degree was in biology education, she explained she was just one course (organic chemistry) shy of meeting requirements for a degree in biology. She had taken courses in evolutionary biology, comparative vertebrate anatomy, animal behavior, invertebrate zoology, and genetics. June had delayed getting a Master's degree because she wanted a Master's degree in biology, not education. She explained, "I just don't know if I am going to be teaching forever. So, I'd rather have a biology Master's." June attended a local workshop presented by a colleague of Neil Shubin, the author of *Your Inner Fish*, which is commonly recommended supplemental reading for evolution in high school biology courses. She had taken other professional development such as a program in which participants observed and analyzed ecosystems from Atlanta to the coast of Georgia, and another workshop on bird identification and adaptations.

June was cautious in her approach to teaching evolution. She was advised once to cover the information while trying not to use the word evolution. She explained, "You can use key terms like adaptation and change over time without making it pop out as the controversial subject. I was told that maybe it's a good idea to say, you don't have to believe in this, but there is evidence to show that it does exist. And that's pretty much the stance in which I teach it." June sometimes introduced the topic of evolution with the story of Charles Darwin and his position as naturalist on the *H. M. S. Beagle*. She felt by relating the story of Darwin and his original career aspiration of becoming a physician, the students could see him as human. She explained,

> So when they kind of understand it from, like a relatable point of view, they don't really argue about it, and they don't really say much, you know.

> Some of them still don't believe dinosaurs are real. They think somebody put those things under the ground. Which I think is really crazy coming from a junior or senior in high school.

June explained the details of how she taught Zoology by using the posters on the walls of her classroom. The posters illustrated the evolution of animals, starting with invertebrates. She explained, "I teach by the cladogram, and we go in order, in evolutionary order, so I start at back about 700 million years ago with certain types of animals, that show up in the fossil record, and we talk about relationships." The Georgia Performance Standards governing Zoology (GPS, 2009) were also posted on the wall above the white board. June elaborated,

> And that kind of goes along, and if you look at all of those, all of those have evolution in them. Standard #1, #2, #3. The only one that doesn't is #5, which is how humans interact with animals. So you have to do key adaptations, as you know, geologic history, cladograms, monophyletic clades. With monophyletic clades that's DNA, that's evolution. So Zoology is highly evolutionarily based. You can't get away from it.

June emphasized that she used anatomical and functional comparisons of organisms to show how animals change slowly over time. To make these comparisons clear, she used color-coded diagrams. Each color was used to show how systems became more and more complex as animals evolved. She gave lectures about transitional species in which she asked students to look at pictures and identify characteristics these transitional species have in common with more primitive groups and more complex groups.

June was surprised at the contradiction between what her students said about their beliefs in evolution and their responses to knowledge gleaned from the course. She stated,

> Personally I don't see how anybody wouldn't believe in it. I don't understand why someone would argue it… And I have had students tell me, you know, at the beginning of the semester, they don't believe in evolution. They don't believe in that. But by the end of the semester, they're talking about it in a way that says they believe it. But if you directly ask them if they believed in evolution, they might still say no. But their statements show that they do.

June also taught about the evidence for dating the fossil record. She said,

> I don't get too much argument on exact number of years. Again, if somebody starts bringing it up, I just say, you don't have to believe in this. There's just evidence to show this. You know, that's just what I do, if I see somebody is really apprehensive. Like I said, usually by the end of the semester, they're speaking as if they believe. But if you ask them directly, they still might say no, which is really weird.

June felt parents and the local community would support her in teaching evolution. She stated most people in the community would be more accepting of language describing organisms changing over time, and adapting to their surroundings, rather than the word evolution. She also felt her colleagues were comfortable teaching evolution, but some might place a greater emphasis on evolution than others. She thought there might be other reasons than religious objection. For example, lack of knowledge of the subject

might account for a feeling of discomfort in teaching it. June was very confident of support for teaching evolution from the administration at her school. She explained, "Yeah, because it's in the standards. Not just a local school community. It's the state standards, and it's in most national standards. So, just because of that, I think there would be support." June explained about her personal beliefs and how they affected her views on the teaching of evolution. She said, although she was raised as a Christian, "I just don't have that religious conflict with it (evolution)."

June's description of her teaching demonstrated thorough content as well as pedagogical content knowledge in her approach to teaching evolution from a scientific standpoint. Her language describing evolution was designed so as not to be confrontational with students who may have religious objections. June believed her fellow science teachers were supportive of teaching evolution in a scientifically rigorous fashion and her administration would support her because of the need to teach standards required by the state. Parents and the community were supportive as well.

Garrett

Garrett taught biology for his entire nine-year teaching career at East Broad High School. His undergraduate degree was in biology education, and his Master's was in adolescent education, both from a local university. He felt well prepared to teach evolution. He stated,

> The way I was exposed to it at university was new to me in the sense that no matter what aspect of biology we were talking about, whether it was photosynthesis or classification or whatever the case might be, it was always in the context of evolution theory. And so, I've tried as much as

> possible, to duplicate that here, in the way I teach it. Because I know that's the way that biologists treat it and view it. It's hard, because the standards tend to pigeon hole evolution as just one unit of the class, so it's a challenge for me to sort of incorporate it throughout the semester.

Garrett's preparation also included student teaching with a "great mentor teacher" at East Broad. He had not completed any professional development directly related to evolution.

Garrett followed the Georgia standards for Biology in teaching his course. For the sake of convenience in grading, Garrett taught a separate unit in evolution. Although he incorporated evolution throughout his course, he felt a separate unit was important because "for most of my students, it's really the first time they've ever had to learn it." Garrett used a modeling activity to introduce students to evolution that simulated how allele frequencies change due to natural selection. The "organisms" (punched paper holes of different colors) are placed on different colored backgrounds, while the predators (students) were not looking. When the predators opened their eyes, they had a certain amount of time to pick up the prey. The organisms left get to "reproduce." Students kept careful counts of allele frequencies, and when they analyzed the data, students determined the shift in allele frequencies. "Natural" selection had occurred, and the population had changed. Garrett followed with other activities using fossil evidence, DNA evidence, and embryological evidence for evolution.

Garrett was always aware of students' reactions to his teaching of evolution. He stated, in a typical class,

> I assume that I'm going to have some of them who don't have a problem with it at all. It's not controversial at all. And then I'm going to have

> some who, who don't like it. Who don't want to learn it, for religious reasons, or whatever. And then, I figure I have a lot of kids in the middle who never even really thought about it before, and they just, they're kind of floating along, you know… I don't emphasize human evolution because I know that it is not emphasized on the state test, and I know that that's the most controversial aspect of it.

Garrett didn't feel his students had a good grasp of what a theory entails. However, he said, "teaching evolution is an opportunity to settle that with them." He used the evolution unit to teach about the nature of science and how a scientific theory is different than how people casually use the word. Garrett did not allow whole class discussion on the potential controversy surrounding evolution. He explained,

> Leading a class discussion about a controversial issue is a challenge in and of itself. No matter what the issue is. So you don't want the train to go off the rails, so to speak. But then the other problem is just time. If I had a whole course on evolution, instead of just a two week unit or something, then maybe there would be a lot more opportunity for that, but I feel like I can't devote a big chunk of a class period just to a discussion, where everybody's sharing their ideas because those ideas aren't going to be on the state test. And in a way too, I feel like if we did have a discussion, it would undermine the content. It would undermine my lessons, even just opening it up for debate undermines the lessons and so, I've never, never, done that. In society at large, it is a debate, and it is controversial. But within the scientific community it's not. It's settled science. And my job

> as a science teacher is to teach them the science. Even though I myself am very familiar with the larger issues, and I know they come in with questions, I choose to ignore it in class.

Garrett explained that he only had one student in nine years who turned in papers and quizzes during the evolution unit with a note, which read, "I don't believe this. My parents say I don't have to learn it." Garrett viewed being devoutly religious himself as an advantage in dealing with this student. Garrett was a deacon in a Southern Baptist church and a Sunday School teacher.

> I just see it as that's how he was raised, and that's how I was raised, and so I talked to him. I explained to him that all you have to do is learn about it (evolution) and be able to answer some questions about it. And prove that you understand it. So he seemed to understand that, and from that day on, he did fine. They've been taught that evolution is wrong, and that it's unBiblical or whatever the case might be, and so they come in already having that negative attitude toward it.

Garrett did not feel particular outside pressure regarding how he approached the teaching of evolution. Any communication he had from parents was resolved amicably. He grew up nearby, and hence, knew the community well. He and his colleagues collaborated on lesson plans and tests, and Garrett believed they were all teaching the same subjects in the same manner. When asked about administrators, he laughed, "Our administrators want us to do whatever the standards say. They want high tests scores on the state tests."

Garrett's personal views did not conflict with his views on evolution. He explained:

> I don't have any personal conflicts. I think if I did I would have addressed those a long time ago. My personal view is a little bit nuanced, though. I guess what I would say is that I feel like science is science, and I think in a lot of people's minds, the reason they don't want to accept evolution as hard science is because in the public's mind, in society's mind, if something is scientific, then that means it's better somehow, that it's elevated. It's this lofty ideal, for knowledge to be scientific knowledge. And so the idea is that if I agree it's (evolution) scientific knowledge, then that means I can't believe my Bible anymore. I can't disagree with any part of it anymore. And certainly if knowledge is scientific knowledge, that means it's been vetted. It's been tested. So I understand that whole process. But at the same time, I would say that science is just one way of knowing things, and one way of learning. And, as humans, we don't have to be limited to that. We can accept things or believe things that are unscientific, and still value the science at the same time.

Garrett taught with confidence about evolution as a controversial topic. Garrett had reflected on his personal views and how he would teach evolution. He knew the content, was secure as a teacher, and understood his position within the culture of the school and the community.

Barbara

Barbara taught in a different high school, but the same system as Garrett and June. Barbara's preparation for teaching evolution was thorough. Her undergraduate degree was in biology from a major university in Texas. Her Master's degree was in curriculum and instruction. She had taught for 12 years, two in a northeastern state and the rest in Georgia. The courses she taught during that time included Biology, Environmental Science, and Zoology. Since the emphasis in her undergraduate degree was in field biology, she had taken many "-ologies," as she referred to them. She took mammology, ichthyology, ornithology, and herpetology. She stated that evolution was heavily embedded in all her coursework. The many workshops in which she participated were science related, but none were specifically on evolution.

I asked Barbara to describe how she taught evolution in her classroom. Instead of describing lesson plans, resources, and labs, Barbara's immediate response concerned her students' inquiries into her personal beliefs,

> Um, well, when you teach evolution, and you say that word, the first thing they ask is, do you believe in God? And so my tactic is to never answer that question. And so, I keep them guessing. And some kids are very persistent. Yeah, I just made that conscious decision to make it a mystery.

Barbara relied on state standards to justify how she approached teaching evolution.

> By not telling them what I believe, and what religious background I am or am not, or whatever, by refusing to do that, it's been effortless. It really has. So they focus more on trying to get me to say what I am and not what I'm trying to teach them. Kind of through the back

> door. So, if you don't relate it to humans, they're ok with it. They don't realize what they're learning. Honestly. Which is sad because it's a huge part of understanding evolution. But, I got to do what the law says. If it says to cover the standards, that's what I do.

Barbara often used the phrase, "change over time" as a synonym for evolution. She explained, "Yes, I do sugarcoat it (evolution). But that's so that my life is a lot easier. In the room. Less arguments."

Barbara did have students who objected to learning evolution. One student said, "Evolution is awful and I'm not going to learn that, and that's not what I learned at home." Barbara's response was to show the student the standards for her class, and to make it clear that she would not be deviating from that document. She explained that her "tactics" were just to deescalate. She noted, "It's easier when you're sweet and nice."

Parents had never challenged Barbara over her teaching of evolution, however, she was wary of administration. She witnessed the firing of one of her colleagues. Her colleague had been confrontational with students and parents in his support of evolution. He was fired in the middle of the school year. Barbara's response was "You can't act like that. If your customers aren't happy, you're not doing what you're supposed to be doing. Teach the standards." Barbara was cautious about teaching evolution since she had seen her colleague lose his job. She explained how her teaching had changed since the incident.

> …it sounds like I'm kind of dumbing down or trying to circumvent this topic that's very important, but there are bigger powers that be than myself,

so, learning from his experience, witnessing it first hand, as a colleague, so I just try to keep my head down.

Barbara felt discouraged about teaching evolution. She said, "Like, I'm going to teach them evolution, and evolution is so cool and awesome, and blah, blah, blah. And after a while, I'm, ahhh, whatever."

Barbara was the only confirmed atheist in the group of teachers I interviewed. She admitted her lack of religious belief reluctantly. She was suspicious of my motives in interviewing her, even though she had consented to the interview. I reassured her schools, school systems, teachers, and references to identifiable place names or people would be referenced by pseudonym only. She accepted my assurances and said, "I was just wondering what the motivation was. Cause sometimes, there's not a good motivation." Barbara also felt persecuted about her beliefs. Finding out her religious beliefs seemed to her to be the number one question from students. According to Barbara, they always ask, "What does the biology teacher do on Sundays?" She had a Darwin bumper sticker on her car when she was in college, but now she felt like she couldn't have one without being interrogated. "Nope, nope, nope, not going to happen," she said. Barbara was a competent biology teacher with a good content background. She felt isolated and threatened over her stance as an atheist. She feared for her job, and she was discouraged about not presenting a thorough picture of evolution.

Lily

Lily had been teaching high school biology for 12 years. She had a Bachelor's degree in biology education, a Master's degree in curriculum and instruction, and an Education Specialist degree in educational leadership. She had begun work on a

doctorate, but had suspended her studies. Lily began her college career majoring in biology, and then switched to biology education. Lily did not feel well prepared to teach biology or evolution when she first began teaching. About her undergraduate preparation, she said, "So you learn a little bit about a lot, and then when you begin to teach biology, you have to know a lot about a lot." With regard to evolution, she said, "I mean, you had a course here and there. But nothing that's standing out in my mind...that really prepared me." Lily thought her best preparation was student teaching. She said, "Because it was, you had to do it. You didn't have a choice. And I had a really great mentor teacher, who everything I did, as a first and second year teacher was based off what she did."

When asked how she actually teaches evolution in her classes, Lily made the first mention of her religious beliefs.

> Well, when it comes to evolution, this is a very passionate topic of mine. Because I personally do not subscribe to the theory of evolution, and I don't, so personally like inside, I'm like, ohhhh. I personally am like a literal 24-7 creationist. So, that being said, people are oftentimes asking me, goodness, how can you teach evolution? Well, I teach evolution because it's part of the biological sciences. It is what it is. So despite that my own personal beliefs are in direct contradiction to the, to what most biological scientists would agree with, subscribe to, it can be kind of challenging, but that at the same time, it is a basis, a foundation, for all the biological sciences, and so, I teach it the way that I'm supposed to. The way that, you know, I think, most other teachers would.

In spite of the fact Lily was a creationist, she felt she could put conviction aside and teach evolution as rigorously as the standards required. However, as an introduction to the topic of evolution, Lily invited her students to consider "there are lots of potential ideas out there, and it is the students' responsibility to research all of those ideas, and come to their own conclusions." Lily elaborated on her instructions to her students in this way, "We will not be talking about anything faith based. I go into the reasons why. And the reasons why we will be talking about the theory of evolution, Darwin, natural selection, all of that kind of stuff." Lily described her motivation for this introduction to evolution in the following way.

> I just don't want to push any of their ideas or previously held notions away initially. Just because I myself don't subscribe to this, I myself don't necessarily agree with this. And I don't want to, I just want their minds to be opened to anything, and I just usually kind of describe it like, if I am a defense attorney, then I need to know the opposing viewpoint. Not, I, of course, think I am right. But I need to know the opposing so that I can better prove my own case. So even though they may not agree with, or subscribe to, the theory of evolution, they still need to know about it. And it's still a valid idea. And theory points that are out there. And vice versa. So you may be a staunch evolutionist, but you still need to know the other side's argument, if not to better prove your own case.

Given that introduction, Lily described the kinds of activities she used. Lily was careful to say that she taught the Georgia Performance Standards for Biology. She discussed Darwin and his experiences on the *H.M.S. Beagle*, natural selection, and variation within

species. Activities included a bird beak lab, designing an organism to fit a particular environment, and readings from *Scientific American* and other sources. Her unit on evolution lasted approximately a week and a half with 90-minute block classes. She sometimes used pictures in the textbook for a discussion of homologous structures and embryological evidence. Although the students studied fossil evidence and the geologic time scale, Lily stated, "The whole time scale is difficult for them, I think, conceptually to understand. When you are talking about millions and millions and millions of years." She went on to say, "…so the whole idea of natural selection, and just, it being based on allele frequencies changing and that kind of thing, it's just difficult for them to understand. I think very few of them actually get it." Lily did not feel her students had a good grasp of what theory means in science.

Lily had never had a challenge to her teaching of evolution from parents, her colleagues, or administration. She attributed the lack of conflict regarding the teaching of evolution to her openness to discussion. She said,

> If they ask me my opinion, then I have no problem telling them. But just going into the fact that I'm a literal, 24-7 creationist, when you have people who, you know, feel the opposite. So I just try to, we're all like open and honest in discussion and all that kind of stuff. But at the same time, like based on biological sciences, based on science in general, that evolution is the foundation. So I don't really feel like I've ever had any conflict when it comes to this. I definitely have kids who have felt, who have either been in one end of the spectrum or the other. But I don't feel it's ever caused a problem. It's just been discussed, and looked at the

> evidence that supported and the evidence that doesn't support or whatever. When kids ask questions, I describe it as a car accident. You could have two different investigators who have all the same pieces of evidence, but who come to very different conclusions. And so, you know, creation scientists, evolutionary scientists; they have all the same pieces of evidence. They just come to two different conclusions. And, I don't know, I've never had any conflict. Either way.

Although Lily described herself as a Young Earth creationist, she claimed to have no problem with teaching about fossil evidence. However, the manner in which she described her internal reaction contradicted this denial. She described her reaction in this way,

> I teach it the way that I'm supposed to, based on the standards. And based on the theory of evolution. In my head, as I'm teaching it, many times I'm like, WHAT? I don't like this. This is crazy. This is ridiculous, you know. Or I'm thinking all of these different things. But I don't necessarily, I don't, present that to the kids. So while internally I may have these conflicting views, I don't think that I present those to the students. Cause I don't talk about it, cause that's not what we're talking about. We're talking about evolution. We're not talking about creationism. If I needed to do a lecture on creationism, I could go and do a whole lecture. I could go into the Greek and Hebrew behind the words. And all that kind of stuff. So I mean I could go into all of that. Cause I have researched that thoroughly. So I could do a whole lecture on that. But I don't because that's not what

> we're doing. That's not, this is not the forum for that. So I don't know, like I said, internally I may have these conflicts, but that's just not what is presented to the students, cause that's not what we're doing. We're not having a debate about creationism versus evolution. We're talking about evolution.

Though Lily said she had no conflict, she invited students to consider alternative views to the scientific view of evolution.

Even though Lily had been teaching high school biology for 12 years, she did not feel comfortable about her preparation. She felt her students did not fully comprehend the fossil record, the definition and application of theory, and the geologic time scale. She spent little time, if any, on human evolution. She also provided class time for discussion of other options to evolution.

Mary

Mary earned her Bachelor's degree in biology in a large western state. She immediately entered a doctoral program in biology but had to drop out after a year. She took a job teaching high school Biology with a provisional teaching certificate. After teaching for five years in California, she moved to Georgia. She began working as a substitute teacher at a high school in the school system where she currently teaches. Overall, Mary taught 14 years, 13 of which were in Biology. Mary emphasized her university background in science. She noted, "I've gotten, I have a science degree. I had more science classes than every science teacher who got an education degree… I learned almost everything about teaching in the classroom, and I learned all my science in university." Mary had taken no classes in science pedagogy or teaching evolution. She

also had not done traditional student teaching. None of her professional development had been in teaching evolution. When asked how she taught evolution, Mary responded,

> I come with the California perspective on evolution, rather than the Georgia Bible belt perspective. I'm a biology major, and from California, and I'm Catholic, so my religion allows for evolution because it's not a literal type of interpretation. All three…of those things have allowed me to kind of be in the classroom and be more open-minded to the teaching of evolution.

In teaching, Mary emphasized a basic understanding of evolution to her students. She was consistently mindful of the end of course test required for Biology in Georgia. She said,

> It's two weeks, and it's a lot of vocabulary that they have to know. And one of the things that I focus on is the definition of evolution because the kids basically go, oh, monkeys, human. And I'm like, if that were true, then we'd have no monkeys left. They'd all be humans.

The students who were resistant to learning about evolution sometimes frustrated Mary. "I have been flat out told by students that their parent said they were allowed to fail this unit… They have this automatic firewall from their religious background, and… they've been taught to be very defensive about their religion and protective of it." Mary made a special effort to create a safe environment in her classroom, both for the students who felt their religion was under attack as well as the students who are what she termed "more liberal minded." Mary presented Darwin's early life as being full of uncertainty because she felt teenagers would be able to see Darwin as more human. After the first three days

of basic vocabulary and a description of Darwin's story, Mary felt she had established some trust with the extreme constituencies in her classes. However, she still proceeded cautiously. She explained,

> I find it's like a mine field that I have to traverse, and I'm exhausted those weeks, because every question, I have to think about very carefully before I answer because like I said, if I say one thing the wrong way, it's like 20 steps back, and those defense mechanisms go up, and then I'm stuck, and I just got to get through it. Because I believe evolution is a major thread in biology. I mean, it's just an underlying thread that connects everything... I want them to be informed voters, you know, not choosing something because of what their mom or their religion says, but because of what they understand about it.

Mary always felt supported by administration. With regard to colleagues, Mary said, "All of the science teachers I've ever met have believed, have had Christian beliefs, every single one of them. And they never had a problem teaching evolution." Mary stated she never had a parent complain about her teaching of evolution. Mary was very candid about her personal beliefs and whether those beliefs affected her teaching of evolution. She stated,

> You know, this whole Bible belt. It's religion on steroids… I was raised, my parents were, well, you're baptized Catholic, but if you want to be Catholic, that's up to you. I just, I grew up with a very different value system. Not necessarily bad or anything, it was just different... I couldn't

> imagine being a teacher who had these very strict beliefs and then had to teach the subject, with conviction. That would be a challenge.

Mary felt prepared to teach evolution. She was thoughtful about presenting it in a fashion that would not alienate students. She had not had direct challenges from parents, administration, or colleagues, although she sometimes felt frustrated by students' lack of acceptance of evolution.

Catherine

Catherine had a Bachelor's degree in political science and environmental studies from a Midwestern university. She originally planned to go to law school, but changed her mind after being admitted, and got a job as a teacher. Although teaching was supposed to be temporary, she discovered she enjoyed it. She had a varied career, teaching special education, social studies, and finally, science. While teaching in North Carolina, she obtained National Board for Professional Teaching Standards (NBPTS) certification. After moving to Georgia, she earned a Master's degree in science education, and an Education Specialist's degree in secondary science education. Her combined teaching experience included 20 years in middle school and high school. At the time of our interview, she taught Biology and Environmental Science at Cannon High School.

Catherine participated in professional development that she believed improved her content knowledge of evolution. She particularly mentioned participating in evolution workshops at a nearby university. In her teaching of evolution, Catherine used many ideas gleaned from her participation in professional development. She included PBS Nova videos, a bird beak adaptation lab, whale evolution, and other online materials in her lessons. Most students responded well to the materials she chose to teach

evolution. However, a few students objected. One incident resulted in a conflict with the administration.

> Our principal called me up to the office about teaching evolution. He said, you're not respecting their religious beliefs. Which I said there's no room for. It's not religion. That's in a private school. And so if you want it to be a religion class, you would chose to go to a school that provided you with religion classes. And this is public school, and we're just going with the science here. I felt like he was telling me just don't do it. Don't teach it at all. I said, it's part of the curriculum.

Catherine felt other teachers at her school taught the scientific viewpoint of evolution with one exception, a teacher who simply avoided teaching it. Most of the teachers taught evolution because they were generally expected to teach biology with the same lesson plans, evaluations, labs, and other activities. Catherine believed, with the exception of her current principal, administration would support her teaching of evolution.

Catherine's personal religious views did not conflict with her teaching of evolution. She was raised as a Catholic and for her, evolution was "not an issue." She said, "For me, I can't understand. It's like, here, you can have both if you want. You can have your science here, and this is your faith." Even though Catherine had a varied career, she was prepared as well as passionate about teaching evolution.

Molly

Molly had twenty-two years teaching experience in high school and middle school science, with 20 of those years in biology. Molly had a Bachelor's degree in biology, a Master's degree in science education, and a doctorate in curriculum and

instruction, with an emphasis in science education. Her doctoral research was on the nature of science. Her preparation for teaching evolution came mainly from her undergraduate education, although she specifically mentioned a Master's program Earth science course, which had an emphasis on evolution. She did not have student teaching because she started teaching public school with provisional certification, and her prior teaching experience exempted her from student teaching when she received full certification. She did not feel well prepared for teaching evolution by her undergraduate studies. She stated,

> I don't think I have been really prepared well for it. Just because I think I was ignorant going into teaching about evolution. And I have educated myself on it. I don't have a problem with anything controversial because I love that. I love to take the controversy and use that to engage students.

Molly's current experience with teaching Biology was in an International Baccalaureate endorsed high school. She taught both year one, or introductory Biology, and year two, advanced Biology. She stated that year one focused on an array of standard topics in biology, but year two concentrated heavily on evolution, particularly human evolution, at the beginning of the year. One of Molly's favorite activities in teaching human evolution was called "dating a hominid." In this activity, students researched examples of hominid fossils, and arranged them on a timeline. Students were then challenged to come up with their own ideas about what may have happened in human evolution over the period of the timeline. Molly contrasted her current teaching assignment in an urban school system to another time when she taught at a more rural high school. She stated evolution was not

stressed in her former school. She felt teachers were encouraged to focus on teaching only what they would be held accountable for on the state test for Biology.

Regarding challenges in teaching evolution, Molly said, in her previous school, it was not unusual for students to say, "Well, I don't believe in evolution." Molly stated she tried to help students differentiate between a belief system and a scientific viewpoint. Molly had few challenges from her colleagues, parents, or the community in general. Molly always felt she had administrative support. For parents, "any of the concerns that I've had have been more from misinformation going out, and once I talked with the parent, they were fine." Molly felt in her current school she did not get parental complaints because the general level of education of the parents was high. Molly believed her colleagues were very supportive of teaching the scientific viewpoint of evolution.

Molly's personal views on religion did not conflict with her stance on teaching the scientific viewpoint of evolution. Molly explained,

> I am very religious. And I go to a Methodist church, and there have been some people there that have questioned me in a good way, and have allowed me to explain my thinking and my understanding of science… For me, I have absolutely no problem with thinking that it (the universe) was orchestrated for me from God. That God has his/her/its hands involved in the formation of this. And I mean, for me, the more I know of science, the stronger my faith is.

Molly enjoyed teaching evolution. She was comfortable with her understanding of the dichotomy of science and her faith.

Virginia

Prior to my interview with her, Virginia had been teaching Biology at Stephens High School for three years. Virginia attended Stephens High School herself before attending a small liberal arts college in North Carolina where she received her degree in biology. Because she wanted to become a teacher, she took a suite of education courses and student taught during her final semester of college. She did not take a specific class in evolution as part of her undergraduate degree, but remembered evolution as a common thread in her biology courses.

Virginia explained she taught evolution as a "full unit," called "how changes to DNA fuel evolution by means of natural selection." The topics of the unit included natural selection, adaptations, analogous and homologous structures, vestigial structures, the fossil record, biogeography, cladograms, and dichotomous keys. Virginia also presented case studies. In one case study, students looked at the relationship between susceptibility to malaria and sickle cell disease. In another, students studied the possible evolutionary link between salt related hypertension and African American populations. Virginia explained to her students how scientists use the word theory, especially with respect to evolution.

Virginia noted how some students react to evolution in general and human evolution in particular. She forestalled questions about how religion and evolution might clash for some students. She said, "I'm sure I've had kids say, the Bible says something different. At which point, we just have a brief discussion. In class, we focus on the evidence and this is what the evidence shows."

Virginia did not have any particular conflicts or objections from parents or administration. Judging from collaborative discussions with her colleagues, Virginia believed her colleagues taught evolution from a scientific standpoint. Virginia did not have any conflicts with evolution and her own personal beliefs. She explained,

> I'm not a particularly religious person. I did not grow up going to church. I'm aware of the Genesis story. I don't know what I believe about God or anything like that. But, if I did believe in God, I think it's a cooler idea that there was some being that set this whole universe in motion, not just what happens on Earth, and so I take great pleasure in teaching a concept that illustrates how we're all connected… I think evolution is awesome, and I try to have my students at least be a little enthusiastic about it as well.

Virginia was well prepared to teach evolution, did not have significant sociocultural challenges, and did not have personal or religious conflicts with the scientific viewpoint of evolution.

Tracey

Tracey had a Bachelor's degree in biology, and a Master's degree in science education, with a special focus in biology. She had been teaching for 29 years, mostly in high school. She had only one class in biology education, and no student teaching. She began teaching with a provisional certification, and she was allowed to use her provisional teaching experience to count as student teaching. She expressed strongly her opinion that teachers who teach science should have a degree in science. She said her biology courses, both undergraduate and graduate, placed a strong emphasis on evolution, and she felt well prepared to teach evolution. Her professional development included a

summer workshop on evolution at a nearby university. She had not had any special training for teaching evolution as a controversial topic. On her own, she said, "I had to learn a way of introducing the topic that doesn't send everybody running for the door."

Tracey used a variety of activities in her teaching of evolution. Beginning with a discussion of the nature of science was important to set the stage for evolution. A sampling of activities included using pipe cleaners to illustrate natural selection, a coloring activity to illustrate homologous structures, and an activity using playing cards to illustrate evolution of the vertebrate eye. She used Kenneth Miller's mousetrap video, and material from a website called Biointeractive. She also included a discussion of religion and its influence on acceptance of evolution. As an initiating strategy for a writing activity on religion and evolution, she used a video clip of an African American minister talking about how evolution and faith do not have to conflict. Tracey had a few students protest learning about evolution. She explained, "I'll have a couple that'll say it doesn't matter what you tell me, this is what I'm going to believe, but I've only had, maybe three students tell me that in the last four years."

Tracey felt her colleagues were supportive of the manner in which she approached the teaching of evolution and taught it in a similar fashion. She also felt her administration supported her. She added, "It's something that we're required to teach, so we're expected to do that." Tracey's personal beliefs did not conflict with her views on the teaching of evolution. She said, "I always tell them (students) right up front that I am a believer and I'm a scientist, and the two do not have to conflict. I think a God that could make a world that could evolve is a glorious God." Tracey had few challenges in

her teaching of evolution. She felt well prepared and was not hesitant to discuss religion and the nature of science.

Terrie

Terrie taught AP Biology at Susan B. Anthony High School. She had 23 years experience teaching science. She earned a Bachelor's degree in biology, and a Master's degree and an Education Specialist's degree in science education. Terrie felt she was well prepared to teach evolution from a content perspective because of her undergraduate degree in biology. She also had done professional development in a summer workshop specifically on evolution. She identified this workshop as one of the most valuable experiences she had on the topic of evolution.

Terrie used a number of activities, labs, and readings to teach evolution. She stated she incorporated evolution in everything she taught. She did an activity on human evolution in which students looked at skulls of various primates and observed differences and similarities. She led a variation on a bird beak adaptation activity, an exercise on dinosaur structure and function, cladograms, and readings on evolution from non-textbook sources. She felt comfortable talking with students about their religious reservations concerning evolution. She said, "I talk to students that may want to say that, at my church, they say don't talk about that. I may have maybe one or two students that may say that each year." Terrie talked with students about her own religious beliefs and how the appearance of life on Earth coincided with her interpretation of the Bible. She stated, "In the Bible, in Genesis, it talks about it (the Earth) was created over a period of time. To me, it kind of matches up with a lot of what I understand in biology." Terrie did not try to change students' personal views about evolution. She explained,

> "I'm not trying to change anything, I just want you to get a, have an appreciation for the subject. You don't have to believe it. It's just, you're just hearing it… One of the things that I say to my students is respect everybody's opinions."

Terrie did not have objections from parents or from administration. She felt that her colleagues were all similar in their approach in teaching evolution scientifically. Terrie did not feel her personal views conflicted with the scientific viewpoint of teaching evolution. She expressed what she saw as the correspondence between the scientific view of evolution by natural selection and her personal theistic, Christian viewpoint. She emphasized she did not express her religious views in class, but she did encourage discussion on how students' religious viewpoints may or may not be in line with scientific thinking.

Carey

Carey taught 7th grade life science at Henry Middle School. She taught a total of 4 years, with two of those years in life science. Carey was well prepared to teach life science. She had an undergraduate degree in biology and a Master of Arts degree in teaching. Her Master's degree was a one year condensed program on how and why we teach science, which also included science content courses. Part of her coursework included evolution and evolutionary medicine. One of her science pedagogy courses had addressed how to handle controversial issues in the classroom. Carey was well prepared in content and pedagogy to teach evolution.

Carey taught evolution in her classes with a variety of activities, labs, and other resources. These included antibiotic resistance, evolution of peppered moths, Brain Pop

videos, online simulations, readings from the textbook, and bird beak adaptations. She stated the bird beak activity was one of her students' favorite labs of the entire school year.

Carey had faced no challenges from students or parents about her teaching of evolution. She stated, "I've only found students to be supportive or curious or interested in learning more about this. I've never faced anyone who seemed uncomfortable." Since Carey planned instruction with her colleagues collaboratively, she felt her colleagues taught evolution with the same attention to scientific validity as she did. Carey felt she had the support of administration. She elaborated, "Because it's (evolution) a Georgia standard, the things that we address in our class, (are supported). So I think that my administrators support me in teaching the standards and teaching good science. I also think if I was in a situation where a parent was questioning me, that I would have their support." Concerning human evolution, she said, "Currently, we don't really teach about the evolution of humans, so I haven't addressed it in any extended way. But that's something that I would like to do. It's just the, the constant struggle of where to give your time."

Carey did not have any conflicts with how she taught evolution versus how she personally viewed evolution. She did not describe herself as a religious person. However, she related a story about her own experience as a student that greatly influenced how she currently taught evolution. She explained,

> I'll say one thing that definitely influences how I teach it, is how I was taught in middle and high school because I grew up in a very religious Southern area. And my biology teacher would preface the evolution

> lessons with 'you don't actually have to believe this, but...' I just thought that was very strange because the only time in science that whole year that she said, 'you actually don't have to believe what I'm saying, but...' which is just, to me that's, that's not science. Science is a way of collecting evidence about the world, and providing the best explanation possible for the things that we observe around us, and I think evolution can be taught that way even with personal conflicts so my advice for people who are in teacher preparation is even if you're, if you have personal conflicts with it, you're, you're teaching your students about the scientific process, and the theory of evolution is one, is one outcome of that process.

The influence of Carey's own biology education carried over into her present teaching in a way that made her want to change what she saw as bias so her students would have a clearer understanding of the scientific viewpoint of evolution.

Keelin

Keelin taught life science at Henry Middle School. At the time of the interview, Keelin had taught science for 8 years, 4 years in life science, all at the same school. She had a Bachelor's degree in biology. She felt she was well prepared to teach evolution because her undergraduate biology classes incorporated evolution as an important theme. Her teacher preparation was an alternative program known as GaTAPP (Georgia Teacher Alternative Preparation Program). Keelin spent 6 months in evening classes before she found a teaching job. While teaching full time, she spent another year creating a teaching portfolio and meeting with advisors. Her alternative preparation did not include any specific classes about teaching biology or science, and little instruction on teaching

controversial topics. Her first year of teaching in the alternative program counted as student teaching for certification purposes. Keelin had not had any specific professional development in biology since graduation. She did participate in a summer program, which recruited under-represented populations to participate in environmental conservation activities. Keelin's role in that program was mentoring. She believed her training and experience in this program helped with her competency as a biology teacher.

Keelin taught evolution by focusing on natural selection and adaptation. Although she did standard lab activities like a bird beak adaptations lab and a peppered moth lab, she rarely used the word "evolution." The bird beak lab was rated by students as one of the best activities of the year. On her bookshelf, she had *The Beak of the Finch* (1994*)*, which described Rosemary and Peter Grant's experimental studies of the finches of the Galapagos Islands. Every year several of her students were interested enough to borrow and read her copy of the book. Keelin felt although she did a good job with natural selection, she didn't do enough with the big picture. She said, "We do pockets really well, but we don't paint the big canvas." When students brought up topics she perceived as controversial, she said, "So I usually, I'm not proud of this, but I usually kind of sidebar it. And talk to the kids individually, and just, I leave it at that. With an individual conversation." Keelin felt the reason for her attitude was her origins in New England. When she started her teacher preparation program in Georgia, she said, "…and that's when I was like, oh yeah, this is going to be potentially an issue. But then I started looking at this school system (where she teaches now), and I thought, of all places, it's probably not going to be an issue here." Keelin did not have students verbally object to the teaching of evolution. She explained,

> I've never had a kid just say, well, I don't believe that, or sometimes, I hear little mutterings about how, well, my mom says… And I never felt the need to go and talk to the kid one on one because then they were fully engaged in the lesson… My only challenge is I guess not feeling confident enough to really showcase it.

Keelin never had a parent object to her teaching of evolution. During "curriculum night," a large group meeting for PTA, Keelin said, "I always wonder if anyone's going to say anything about that, about when I say evolution and ecology. And no one has." Regarding administrative support, Keelin responded, "So, administration doesn't know what we're teaching, as far as the day to day, how we discuss certain topics." She felt if an issue arose with a parent objecting, administration would mediate and would be supportive.

Keelin had no conflict between her teaching of evolution and her personal or religious views. She explained,

> Can I start by saying that evolution is not naturally controversial to me, and I feel that way because I was not raised with any religion at all. So being in Maine, and being in Pennsylvania, well maybe I was just oblivious to it, and going to school in Vermont, it was like, no, it didn't really come up very much as a controversial thing.

Around the time Keelin moved to Georgia, a court case, Selman v. Cobb County School System was in the news. The issue was the requirement by the school system for cautionary stickers in biology textbooks concerning the teaching of evolution. She said, "So that was just in my head just because it was all over the news, so I was like, this is a

thing here, ok. So maybe that was a broad generalization, but it was in my head." Keelin's perception of how parents or the community might react to the teaching of evolution was tempered by this event, and affected her openness to teaching it 10 years later.

Ulpa

Ulpa taught at Greene Middle School in an urban school system. She had taught for 15 years. Ulpa was well prepared to teach evolution. Her undergraduate degree was in clinical health science. She worked in an immunohematology lab before she earned a Master's degree in science education and entered teaching as a second career.

Ulpa's philosophy for teaching science included an emphasis on how science is governed by evidence. She explained, "You can't get emotional with anything. You can't get, too caught up, in a lot of things." She recalled one of the first times she taught evolution at her current school. She said,

> I remember this student, named Charles, when I was teaching evolution, he said, well, Ms. B., 'I don't believe in evolution.' I said, 'What do you mean, you don't believe in evolution? He said, 'Well, the church I go to, we don't believe in evolution.' I said, 'Well, you may not believe in it, which is fine. Just know that you need to know these facts in order to pass my test. You don't have to believe in it. I just need for you to know this.

Ulpa included activities on bird beak adaptation, fossils, genetic mutation, common ancestors, homologous structures, and the evolution of various organisms such as plants, dogs, and whales.

Ulpa had never had objections or challenges from parents over her teaching of evolution. She had also never had issues with administrators who were unhappy with how she taught evolution. She said, "If a parent has said something to an administrator, it has never gotten back to me." She believed her colleagues taught evolution the way she taught it. All of Ulpa's science colleagues who taught the same grade level planned lessons together.

Ulpa's personal and religious views did not conflict with her teaching of evolution. She explained,

> Obviously, I believe in evolution. And I'm raised Christian. Somebody may say, well, how can you be a Christian and believe in evolution? I say, well, the evidence is there. You can't really, it's not like you need to believe in one or the other. I think that they both can exist together. Nobody knows the power of God. You go back, and you read the Bible, and you go through he created the heavens and the Earth. When you look at the evolution of the Earth, the way that they state it in the Bible, is how it looks evolutionarily.

Ulpa's experience as a teacher and her education in science helped her deal with the few challenges that arose in her teaching of evolution. She experienced little or no conflict with parents, administration, or her colleagues. She reconciled her religious and personal views with her desire to teach evolution in a scientifically rigorous fashion.

Joseph

Joseph had been teaching public school for 13 years at the time of our interview. Joseph was well prepared for teaching evolution. He had a Bachelor's and Master's

degree in biology. After graduation with a Master's degree, Joseph visited his home state of New York. There he ran into a former high school teacher who encouraged him to consider teaching. While in New York, Joseph had an interview with a charter school organization that was opening a school in Georgia. This organization offered him a job teaching middle school life science when he finished his teacher certification course work. Six months later, Joseph took the job. The school was generous in providing materials and equipment for teaching science. They also provided professional development for new teachers to implement the science curriculum. Joseph enjoyed the professional development and the opportunity to use the materials and equipment in his new position.

Teaching at the new school was sometimes a challenge. Parents were required to come to the school to do volunteer work, so it gave Joseph an opportunity to get to know the families well. However, Joseph remained cautious about teaching evolution. Early in the school year, during a curriculum meeting at the school, he related,

> You have a little grandma that came up, and she goes, 'Are ya'll teaching about that stuff that they ain't no Jesus?' I said, 'No, ma'am, we're not teaching that. I said, no, no, no, we're not teaching there ain't no Jesus.' But I knew her intentions were good. She said, 'It's the only way to Heaven, it's the Lord.' I said, 'Yes, ma'am, you know, we teach science. We're not talking anti-Jesus.'

Later, after other complaints, Joseph became afraid that he would lose his job over complaints about teaching evolution. His principal supported him. Joseph described the situation like this.

> Oh, I was afraid. It was my first time in teaching this stuff. She (the parent) was really talking. I'm just doing what is in the book. This is what I have to teach. These are my standards, and this is going to be tested. She said, 'Well, we don't believe in that book. My son has been washed in the blood of the lamb, and you can't teach him this.'

Joseph's principal told him not to worry. She said, "She's just selling wolf tickets." In other words, the parent was trying to recruit other parents to object to the teaching of evolution. The principal reassured Joseph she would support him.

The school's material support and training for teaching evolution was excellent. Joseph described the kit for peppered moth evolution, which came with white and gray colored plastic moths and fake tree trunks. He also had a kit for simulation of the environment of the Galapagos Islands and the finches of the islands. Included in the kit were different bird "beaks" for a finch beak adaptation activity.

Joseph continued to be concerned about parent opinion over teaching evolution. After Joseph left the charter school, he took a job at a middle school in another system. At Joseph's second school, when he introduced evolution, a student objected. She said, "Well, I don't believe any of that." Joseph knew the student came from an educated family. He said,

> I knew that I had to tread the waters carefully with this student. I said, well listen, you have your right to believe. I'm not here to deter you from your way of picking, as far as religion versus evolution. But I have a job to do. I have to teach what the Georgia standards say I have to teach. And this is what you're going to be tested over.

Joseph spoke to the students' parents. The parents were not concerned about the instruction on evolution, but agreed to allow the student to sit in another teacher's classroom during the instruction on evolution. After a day or two, the student returned to Joseph's classroom. Experiences like these made Joseph reluctant to teach evolution. He often relied on the textbook as justification for the information he taught. He particularly avoided mentioning human evolution.

Joseph was unsure of how his colleagues taught evolution at the charter school. At his second school, he found teachers were open to teaching the scientific version of evolution. He felt he had the support of administration. Joseph did not choose to share his personal and religious views on evolution.

Lisa

Lisa had a Bachelor's degree in special education and a Master's degree in counseling. She had been teaching, primarily in middle school, for 13 years. For most of that time, she had been a special education teacher. As a special education teacher, she spent part of her teaching day assigned as a co-teacher with a subject area teacher. She co-taught science for four years, and taught as the primary subject area teacher in life science for one year. She explained, "I wish I had realized that I enjoyed it so much earlier, then I would have done it (earlier)." In order to obtain certification for teaching middle school science, Lisa had to pass the GACE (Georgia Assessments for the Certification of Educators) test in middle school science. Regarding the requirement of only having to pass a standardized test to teach science, Lisa said, "It's unfortunate in my opinion, but I'm a good teacher, so that's ok."

Lisa did not have any formal preparation for teaching evolution. She said, "I actually grew up going to Catholic schools, so we didn't really learn much about evolution. So I had sort of a mentor teacher that I worked with at my school who was a 6th grade science teacher, and she sort of prepared me for all the discussions." Regarding her preparation for teaching controversial topics, she replied,

> I feel fine. I think that comes back to the counseling background, too. Just making sure before the discussion we talk about how we respect everybody's opinions, and we're not going to do a personal attack on anybody's viewpoint, and we always want to make sure we hear all the sides, and all the information and go from there.

Lisa collaborated closely with the other 7th grade science teachers on scope and sequence of the life science course. Evolution was taught as part of a unit that included ecology. At first lessons were focused on Darwin and his experiences in the Galapagos Islands. Lisa had been cautioned by other teachers not to talk about the beginning of life. When asked to elaborate, she explained it this way, "If they all started as a little land creature and then something started walking and it went from there or if God just created them all." Common activities included a bird beak adaptations lab, a predator/prey simulation with selective survival, and PBS Nature and Nova videos. Lisa felt her students were engaged and interested.

Lisa described one incident in which a student was excused from the classroom because he became very offended and angry by part of the discussion on evolution. When Lisa contacted the student's parents, they were surprised by the student's reaction. She explained, "The parents said, we understand that you have to teach that, and that's

fine, and they were surprised actually that their child was so set on that, because they did not see their child as a particularly religiously oriented person." Although Lisa understood the student's feelings, she felt her job was to present the standards. In addition to the one emotionally charged incident, Lisa had a couple of other students who said, "That's not what we learn at church," but participated in the lessons.

Lisa did not have negative responses from parents about the teaching of evolution in her class, although she did expect it. She said, "The parents who communicate most often with our school are educated and want their children to know about the world and things like that." Lisa did have one persistent and divisive issue with her colleagues concerning the scientific details about the teaching of evolution. Lisa described the disagreement and the circumstances. She said,

> …it's surprising that it happened after we taught it, where the one teacher said any adaptation is the result of a genetic mutation and that's how changes in species happen. It's always through a genetic mutation. And so we had a big discussion about that, because that's not what I taught my kids. That's not what the other science teachers taught their kids, but he seemed to think that that was so, of course, everybody knows that. That he didn't feel the need to bring it up in planning ahead of time. Because that's the only way you teach it.

This disagreement resulted in Lisa's decision not to talk about human evolution in her classes. She felt students would misinterpret her instruction to mean the students were mutants. The consequence of this disagreement was the common exam had to be altered to reflect the way each teacher taught how mutations and evolution were connected. Lisa

felt the school administration was disinterested in helping with this disagreement and wanted teachers to solve their own problems. She felt unsupported in general.

Lisa's personal and religious views did not conflict with the way she taught evolution. She grew up as a Catholic and went to Catholic schools. However, she had grown away from her upbringing as a Catholic. She said, "The Catholic Church and I disagreed on so many topics... In college, I investigated a number of different religions and evolution was the least of my disagreements. So I don't know what they say."

Lisa was happy to be teaching science and generally enjoyed teaching evolution. Although she had one upsetting incident with a student's reaction, she felt her teaching on evolution went well. She did have challenges with her colleagues over the factual details of evolution and with the school administration. She did not feel personal conflict between the teaching of evolution and her personal religious beliefs.

Findings: (RQ1) How do Teachers Describe their Preparation for Teaching Evolution?

Specific data regarding teacher preparation from each teacher is included in Table 4 below. Each teacher was asked about his or her undergraduate and graduate preparation for teaching. An undergraduate degree in biology might be taken as a strong indication of a teacher's preparation for teaching evolution. Nine of the 15 teachers interviewed in this study had Bachelor's degrees in biology. Another teacher indicated that she was one course (organic chemistry) shy of having an undergraduate degree in biology. Another teacher's undergraduate degree was in clinical health science. One of the 15 teachers had both a Bachelor's and Master's degree in biology. Teachers were also asked whether they had received any specific professional development in the

teaching of evolution since completing their undergraduate degrees. Five of the 15 teachers in this study indicated they did receive professional development in the teaching of evolution. Previous research has revealed another factor related to whether or not teachers taught evolution was actual number of years experience teaching. Each teacher's number of years of experience is also listed is Table 4. The relationship of these themes to findings from current literature is discussed in Chapter 5.

Table 4: Teacher Education Preparation, Professional Development for Teaching Evolution, and Number of Years Teaching

Teacher Name	Middle (MS)/ High School (HS)	Degree(s)*	State where Undergraduate Institution Located	Professional Development for Teaching Evolution	Years Teaching
June	HS	B.S., biology education	GA	yes	9
Molly	HS	B.S., biology; M.S., science education; Ph.D., curriculum and instruction	GA	no	22
Barbara	HS	B.S., biology; M.S., education	TX	no	12
Catherine	HS	B.S., political / environmental science; M.S., science education; Ed.S., secondary science	OH	yes	20
Garrett	HS	B.S., biology education; M.S., adolescent education	GA	no	9
Lily	HS	B.S., biology education; M.S., science education;	GA	no	11

		Ed.S., educational leadership			
Virginia	HS	B.S., biology	NC	no	3
Mary	HS	B.S., biology	CA	no	14
Terrie	HS	B.S., biology; M.S., science education; Ed.S., science education	TN	yes	23
Tracey	HS	B.S., biology; M.S., science education	n/a	yes	29
Carey	MS	B.S., biology; M.A.T., science education	GA	no	4
Keelin	MS	B.S., biology	VT	no	8
Joseph	MS	B.S., biology; M.S., biology	GA	yes	13
Ulpa	MS	B.S., clinical health science; M.S., education	NC	no	15
Lisa	MS	B.S., special education; M.S., counseling	NC	no	13

*Bachelor of Science (B.S.)
Master of Science (M.S.)
Master of Arts in Teaching (M.A.T.)
Educational Specialist Degree (Ed.S.)
Doctor of Philosophy (Ph.D.)

Teachers were also asked to describe how well they thought their college experience prepared them to teach evolution. Their responses are summarized in Table 5 below.

Table 5: Teacher Perceptions of Preparation for Teaching Evolution

Teacher Name	Middle (MS) High School (HS)	Interview Data: Teacher Perceptions of Preparation for Teaching Evolution
June	HS	Feels well prepared; took courses in comparative vertebrate biology; good general background in biology.
Molly	HS	Mentioned one specific course in earth science with focus on dinosaurs which helped with understanding of evolution; Ph.D. research focused on nature of science; research assistantship in Ph.D. program that focused on studying teachers and their views on evolution.
Barbara	HS	Did not take specific course in evolution; however, all biology courses in undergraduate degree program had evolution focus.
Catherine	HS	No specific college class in evolution; did not major in science or science education as undergraduate.
Garrett	HS	Heavy emphasis on evolution in all biology coursework; had one specific course in evolution.
Lily	HS	No specific training for teaching evolution.
Virginia	HS	Did not have a specific course in evolution as part of biology major; evolution emphasized as part of other courses.
Mary	HS	Feels like she took more science classes in her biology major than any teacher would who majors in science education.
Terrie	HS	Bachelor's degree in biology causes her to feel well prepared to teach evolution; did not take a specific stand-alone class in evolution.
Tracey	HS	Bachelor's degree in biology and master's in biology (minus thesis) causes her to feel well prepared; took one class on speciation.
Carey	MS	Took specific course in evolution and elective in evolutionary medicine as undergraduate.
Keelin	MS	Did take specific course in evolution in undergraduate program.
Joseph	MS	Because of bachelor's and master's in biology, feels very well prepared.
Ulpa	MS	Bachelor's degree in science, not science education; feels very well prepared to teach evolution because of biology courses.
Lisa	MS	Degree is in special education and counseling; no evolution preparation.

Data from Table 5 indicated most teachers who had majored in biology as an undergraduate or graduate student felt comfortable teaching evolution. Additional

coursework, for example, evolution, evolutionary medicine, speciation, and geology, were mentioned as being particularly helpful in increasing teachers' confidence in their content knowledge of evolution.

Findings: (RQ2) How do Teachers Describe their Teaching of Evolution in Secondary School?

Data from Table 6 indicate common methods or activities teachers in this study used to reinforce important ideas in their teaching of evolution. As mentioned previously, the Georgia Performance Standards (GPS, 2006, 2009) were designed to guide Georgia public secondary biology teachers in their teaching of evolution. Also included in Table 6 is data related to teaching of human evolution by teachers in this study. There is no mention of human evolution in the GPS.

Table 6: Teaching Methods for Evolution and Interview Data Evidence for Inclusion of Human Evolution in Instruction

Teacher Name	Middle School (MS) / High School (HS)	Teaching Activities/ Methods for Evolution	Inclusion of Human Evolution in Instruction Interview Data
June	HS	geologic history, cladograms	And I mean one of the reasons I haven't really completely gone there either is just because I feel like that would push a little bit of a button, you know, for a lot of them. But at that point in the curriculum, because they've had so much evolution all semester, I don't know. I've just never tried it. (laughter)
Molly	HS	"dating" a hominid	We have biology for two years, and one of the options that we chose for our students to study in both standard level and high level (IB) is human evolution.
Barbara	HS	bird beak activity	But anytime you put, you know, not knowing that humans are animals, if

			you don't put humans in there, they, they're ok with it. They're happy to learn it. Evolution. So, that's what I do.
Catherine	HS	adaptations of lemurs in Madagascar, geology, fossils, bird beak lab, simulation using dying off of hairless rabbits, whale evolution, evolution of corn	They're somehow hearing that we're in a direct line with monkeys, and so they're like, oh no we're not. And I'm not coming from a monkey, and a monkey wasn't my ancestor, blah, blah, blah. They, they'll accept the fact that we're animals but they still think that we're different. And we're in charge. And we're somehow better. More valuable.
Garrett	HS	lab like peppered moths but with a generic animal; fossil evidence; DNA evidence; embryological evidence	I don't emphasize human evolution because I know that it not emphasized on the state test, and I know that that's the most controversial aspect of it (evolution). So we don't emphasize that and there's a chapter in their textbook that deals with it, so if they ever ask about human evolution, you know, I point them to that. And say, you know, read this.
Lily	HS	bird beak lab, design an animal best suited to a particular environment, skeletal (skull) structure of primates	And, of course, they always say, you know, that picture of the chimpanzee, you know, morphing into man. And so, we just kind of discuss that, how that's inaccurate, in the sense of the evolutionary theory that at some point we potentially had a common ancestor, but it doesn't mean that we came from chimpanzees, or you know, whatever. So, we just discuss, we go through and discuss that. We don't necessarily discuss too much about human evolution, not more than probably a 30 minute little activity or conversation. Evolution, this is a very passionate topic of mine. Uh, because I personally do not subscribe to the theory of evolution, and so, I personally like inside, I'm like, ohhhh.

			I personally am like a literal 24-7 creationist. But I don't particularly spend, and I don't believe anyone else does, really here (at this high school), spend too much time on human evolution.
Virginia	HS	peppered moths, slavery hypertension hypothesis case study, malaria resistance and sickle cell trait	So, at least in that instance, you do teach about human evolution. Do you ever go into more ancient things? IE: In year one, we do not. In Bio, year 2 that is one of their units. Human evolution is a full unit. So I can't speak to, I can't speak much about it, because I don't teach year 2. But the senior bio class does human evolution.
Mary	HS	biographical info about Darwin, peppered moth lab, lima bean variation, adaptation of human thumb	There's a chapter on human evolution in all our biology books. And I really don't go there. I focus on the basics. But I avoid the human aspect of the bigger picture, cause you have to. You know, they completely, their religions completely separate them from all other life, in a sense. They, nobody else goes to heaven, just humans go to heaven. So, they're naturally inclined to separate humans. You know, they don't, some don't even want to put us in the same classification group as animals. And one of the things that I focus on is the definition of evolution because the kids basically go, oh, monkeys, humans. And I'm like, if that were true then we'd have no monkeys left. (laughter). They'd all be humans.
Terrie	HS	cycle back to evolution in everything taught, skeletal structure, fossil evidence, including human skulls, dinosaurs, bird beaks, cladograms	I have the students look at skulls, and I just have them kind of look at those and they're all different skulls and not even the same. You know, I don't even know where they came from, but the point for the students is to be able to look at differences, but at the same time look at similarities. And then I actually have my students do an

			activity during the first week that deals with a human skull and a primate, some other type of primate.
Tracey	HS	fossil evidence, homologous structures, evolution of the eye, discussion of religion, evolution as an anchor for everything else, Bill Nye video, Kenneth Miller video	And then we look and see whether they're more ape like characteristics or more human like characteristics. And talk about what that means. And how we, you know, again, how we're not evolved from apes, but there are transitional fossils that show the evolution. Because they've all heard that we evolved from apes, and so we talk about how that's not true, and we show the line of descent and how they went that way, and here we are over here. And that's very eye opening for them.
Carey	MS	Antibiotic resistance, peppered moths, Brain Pop videos, online simulations, bird beak activity	Currently, we don't teach in this class, we don't really teach about the evolution of humans, so I haven't addressed it in any extended way. But that's something that I would like to do. It's just the, the constant struggle of where to give your time.
Keelin	MS	bird beak activity, peppered moths	…ever talk about primate evolution or human evolution? IE: Not really. No.
Joseph	MS	bird beaks, peppered moths, Darwin life story, reliance on textbook as authority	Long as you don't mention anything about human, you know, they'll deal with it. You mention anything at all about human and ape, they think you're hard-core, anti-Jesus, anti-religious, you know, people will come after you.
Ulpa	MS	Darwin and the finches, evolution of the dog, peppered moths, evolution of the whale, evolution of the horse	I think that the kids think that evolution states that man came from apes. And that's not what evolution is about. We talk about common ancestors.
Lisa	MS	Darwin life story, bird beaks, Brain Pop or nature videos, discussion of different	…but did you specifically do human evolution at all? IE: No, because that was around the time where the conversation about the genetic mutation was the only way for

	religious beliefs, tying evolution to other topics in biology	changes to happen came up. And, as a science team, we couldn't agree.

Table 6 indicated there are some commonalities in instructional activities among Georgia biology teachers, even across middle and high school levels. For example, a number of teachers used a bird beak lab activity. This activity is based on the variation of bird beak types and sizes among the species of finches found on the Galapagos Islands. This variation was observed by Charles Darwin in the 1830's and has more recently been studied by Rosemary and Peter Grant (Weiner, 1994). Also evident from the data in Table 6 is the low prevalence of the teaching of human evolution among the teachers in this study. Ten of the 15 participants did not teach human evolution, and three taught evolution in a limited manner. Only two teachers taught human evolution in depth, either as a full unit in advanced biology, or as part of an activity using primate skulls in which students made and discussed comparisons across human ancestor species.

Findings: (RQ3) How do Teachers Describe the Institutional and Sociocultural Influences that Affect Teachers' Decisions about What and How to Teach Evolution?

This study revealed the influence of a number of institutional and sociocultural factors on Georgia teachers' decisions about what and how to teach evolution. These factors included: (1) teachers' perceptions of the religious/philosophical viewpoints of their constituencies (administration, parents, and students), (2) the influence of state policy makers who are responsible for the creation and imposition of educational standards that guided the teachers' teaching of evolution, and (3) the teachers' own philosophical/religious viewpoints.

The purpose of this study was to understand teachers' experiences and beliefs of teaching evolution within the context of public schooling in Georgia. Participants in this study were Georgia secondary teachers who taught science standards related to evolution within the previous one to two school years. All teachers in the qualitative study reported here were familiar with the evolution standards for the state of Georgia. They were also aware of their responsibility to teach the evolution standards. A number of the biology teachers in this study specifically mentioned, "teaching the standards."

In Georgia, core courses taught in public school have educational performance standards (Georgia Performance Standards, 2006, 2009). In addition, some secondary school science courses may have additional standards imposed by Advanced Placement (AP) and International Baccalaureate (IB) programs. Educational standards are meant to specify what students in a particular course understand and are able to do. According to the Georgia Performance Standards website (2015), standards are written to guide instruction. In this study, data revealed educational standards assumed additional functions in different teaching settings in addition to guiding instruction.

Berkman and Plutzer (2010, p. 24) described biology standards as the "official policies concerning what students should learn in their public biology classes." "Principals" are those state policy makers and their appointees in a bureaucracy who write laws and rules that govern the development of standards. State policy makers are subject to electoral constraints. "Agents" are those who carry out those rules and laws. Teachers are agents who operate at the "street level" in the schools. Teachers may thus be described as "street level bureaucrats" who are responsible for implementing policies that very few of them had a significant role in creating. In a system that is as highly

decentralized as public school teaching generally, there is considerable latitude in how and if educational standards function. Standards may indeed function differently than public policy makers may have originally intended.

This study demonstrated how teachers might limit the implementation of some standards to exclude certain topics related to the teaching of evolution due to their perceptions of the parents' and/or students' potential objections. June was a high school teacher who taught Zoology. The standards for Zoology were laden with the language of evolution (Georgia Performance Standards, 2009). Evolution provided the framework for Zoology standards and thus could not avoided. Vertebrates were one of the taxa specifically mentioned in the Zoology standards. June explained, "In the zoology curriculum, we have to cover these phyla. As long as we cover these phyla, within Chordata, of course, fish, amphibian, reptiles, birds, and mammals, then we've covered our standards." Of course, humans are mammals, and yet June chose to exclude them in her Zoology course. She explained her primary reasoning this way: "One of the reasons I haven't really completely gone there either is just because I feel like that would push a little bit of a button, you know, for a lot of them (students)." June was able to avoid mentioning human evolution because she had already included other mammals in her teaching. At the same time and perhaps more importantly, she was able to avoid her students' possible objections to human evolution.

Standards can also be used to lend the implied authority of the state policy makers and local administrators to the teaching of evolution. Teachers can point to their specific inclusion of teaching evolution in their courses because the standards define and sanction what is to be taught. This inclusion allowed teachers to avoid the controversy that might

ensue concerning topics that might stir controversy in the teachers' unique sociocultural setting. Several teachers in this study used this tactic as a means of deflecting parents, students, or community objections. Responsibility was thus transferred from the teacher to the standards. June, a high school teacher for 9 years, posted a listing of Zoology course standards on the wall above her whiteboard. She explained, early in the class, "I point to the standards. I explain it and say, if this is something that you don't want to study, then you don't need to be in this class." Garrett, a high school biology teacher in the same school as June, explained that his adherence to the standards meant he was teaching what he was supposed to teach. He felt confident his administrators would support him on this point. He stated, "Yeah, they want us to do whatever the standards say. Our administrators want high test scores on the state tests. That's what they want. So we need to teach whatever we're supposed to teach."

Another use of the teaching standards was evident in the practice of two other study participants. One teacher invoked the standards to assure others she was teaching what she was supposed to teach. Lily was a "24-7 creationist" who was adamant she taught the standards for evolution faithfully. She said, "I mean, in terms of how I teach it, I teach it the way that I'm supposed to, based on the standards. And based on the theory of evolution." Joseph, a middle school teacher, taught in a conservative religious community. When confronted by a student's parent over contradicting their religious views by teaching evolution, Joseph replied, "I have to teach what the Georgia standards say I have to teach. And this is what you're going to be tested over. And a great deal of this test is going to be over evolution and natural selection and things of that nature." These two teachers, Lily and Joseph, although they had very different approaches to the

teaching of evolution, used the standards to buffer themselves from criticism concerning their teaching.

Religious affiliation of teachers in this study had an influence on their belief in evolution and how they presented evolution in their classrooms. According to the Pew Research Center on Religion and Public Life (2015), religious identification of the population of Georgia can be classified as 79% Christian, 3% non-Christian faiths, and 18% non-religious. For the U.S. population as a whole, 70.6% are Christian, 5.9% are non-Christian, and 22.8% are unaffiliated/non-religious. Evident from these statistics is a greater percentage of Georgians, almost 8%, identify as Christian than those who identify as Christians nationally. Also, a smaller percent (3%) of Georgians identify themselves as non-religious compared to the national percentage. As a subset of the Georgia population at large, teachers in Georgia probably fall roughly into these same categories and percentages. In any case, these numbers indicate that Christianity is the predominant religious tradition in Georgia.

Examining specific beliefs more closely, the Pew Research Center on Religion and Public Life (2015) investigated the level of agreement among U.S. respondents with the statement that evolution is the best explanation for the origin of human life on Earth. Table 7 shows the only non-Christian category of religious belief in which there is a less than 50% belief in evolution is Muslim. However, Muslims represent less than 1% of religious affiliation in Georgia. These numbers imply that many categories of Christian believers do not believe humans evolved. Fewer than 50% of Muslims, Historically Black Protestants, Evangelical Protestants, Mormons, and Jehovah Witnesses believe in human evolution. Mainline Protestants are close with only 51% believing in human

evolution, but less than 60% of Orthodox Christians and Catholics are believers in human evolution.

Table 7: Percentage of Each Religious Category who Agree Evolution is the Best Explanation for the Origin of Human Life on Earth

Category	**Percentage**
Catholic	58
Orthodox Christians	54
Mainline Protestant	51
Muslim	45
Historically Black Protestant	38
Evangelical Protestant	24
Mormon	22
Jehovah's Witness	8

In table 8, I have used data from interviews to classify the teachers in this study using the categories defined by Scott (2010). To view a more detailed explanation of the categories in Scott's continuum of religious/philosophical beliefs of individuals with respect to evolution or creationism, see Table 1 in Chapter 2.

Table 8: Teacher Position on the Creation/Evolution Continuum (from Scott, 2010)

High School/ Teacher Name	Creation/Evolution Continuum Position	Interview Data
June	Agnostic Evolutionism/Materialist Evolutionism	I was raised Christian, but I don't really associate myself as a Christian. And I think that, I just don't have that religious conflict with it.
Garrett	Theistic Evolution	I think it's just, people who dismiss science, they don't, they just don't understand what science really is, and how it works. And then people who dismiss faith also don't, you know, maybe they're a little bit too, too obsessed with science, or something, I don't know but I don't have a problem with both.
Barbara	Materialist Evolutionism	And I think that it is kind of a, what do they call it, a double standard that other people can be very vocal about their beliefs, and I can't. Because obviously I'm atheist, so I can't tell, you know, everybody. I can't be like, "I'm atheist, you know."
Lily	Young Earth Creationism	Because I personally do not subscribe to the theory of evolution, and so personally like inside, I'm like, ohhhh. I personally am like a literal 24-7 creationist. I would describe myself as a young Earth creationist.
Mary	Theistic Evolution	I was raised, my parents were, well, you're baptized Catholic, but if you want to be Catholic, that's up to you. I grew up with a, with a very different value system. I couldn't imagine being a teacher who had these very strict beliefs and then had to teach the subject. With conviction. That would be a challenge.
Catherine	Theistic Evolution	I was raised Catholic. Evolution is not an issue. It is just a non-issue. Really, I don't know, I think that it's difficult for everyone who, if they take the Bible literally…
Molly	Theistic Evolution	I have absolutely no problem with that, thinking that, that's how it happened, and it was orchestrated for me from God. That God has his/her/its hands involved in the formation of this. And that, I just think it's way cool.

Virginia	Agnostic Evolutionism	I don't necessarily know what I believe about God or anything like that. But, if I did believe in God, like I said before, I think it's a cooler idea that there was some being that set this whole universe into motion.
Tracey	Theistic Evolution	I think a God that could make the world that could evolve is a glorious God.
Terrie	Day-Age Creationism / Progressive Creationism	In the Bible, in Genesis, it talks about it was created over a period of time. To me it kind of matches up with a lot of what I understand in biology. And you know, when they say, well, what about time, they say it was created in a day, I said, well, first of all, a day at that point was not like a day today. When we talk about a day as being night and day, that would not have been a day. It could have been over many years, many periods of time, so it's really hard to put our, put time today the way we know time, into perspective compared to back when some of the first organisms were on earth. I do put my own personal spin on it you have all of these things being created, and then you have man that was created, and I am a Christian. I do believe, you know, in the Bible and things like, like I say, I go back and I can tie it into that.

Middle School/ Teacher Name	**Creation/Evolution Continuum Position**	**Interview Data**
Carey	Materialist Evolutionism	Any personal conflicts with how you teach evolution versus how you personally view evolution? No, there are no conflicts. Would you describe yourself as a religious person? No.
Keelin	Materialist Evolutionism	Well, let me start, can I start by saying that evolution is not naturally controversial to me, and I feel that way because I was not raised with any religion at all…
Ulpa	Theistic Evolution	You know, I believe, obviously, I believe in evolution. And I'm raised Christian, so, somebody may say, well, how can you be a Christian and believe in evolution? So I say, well the evidence is there. You can't really, it's not like you need to believe in one or the other. I think that they both can exist together.

Lisa	Agnostic Evolutionism	The Catholic Church and I disagreed on so many topics that we, yeah, I went to Catholic school through 12th grade. And then I went away to college, and sort of investigated a number of different religions and evolution was the least of my disagreements.

Some teachers on this continuum allowed and even encouraged class discussion on non-scientific explanations for evolution. For Lily, a young Earth creationist, and Terrie, a day-age/progressive creationist, whole class discussion provided an opportunity to encourage "openness" in entertaining explanations other than the scientific viewpoint expressed in biology standards. Lily stated the reason she encouraged discussion was, "I just want their minds to be opened to anything, and I just usually kind of describe it like, if I am a defense attorney, then I need to know the opposing viewpoint." She explained, "Whenever I teach evolution, I kind of give a little introductory spiel, just about how there are lots of potential ideas out there, and it is their responsibility to research all of those ideas, and come to their own conclusions." Lily didn't have any reservations about telling students her beliefs. She said, "If they ask me my opinion, then I have no problem telling them."

Terrie, who taught AP Biology, also encouraged open discussion, which included an invitation to consider other explanations for evolution. Terrie introduced the Bible's Genesis story. She stated, "It (Genesis) talks about it was created over a period of time. It kind of matches up with a lot of what I understand in biology." When her students asked how, in Genesis, creation took place over a period of days, Terrie said, "Well, first of all, a day at that time was not like a day now because it was, the temperature was different." Not only was Terrie encouraging a non-scientific viewpoint on evolution,

there is no scientific reason temperature would affect the rotational period of the Earth. Terrie told her students who had questions to research their questions independently. She continued, "So, I tell them also that it's not about me trying to… force something on you, but in education, it's about you learning… then you're going to get your own perspective, so whatever I say, don't believe what I say, but read, go get more information… and be able to be a part of the conversation." By encouraging this free ranging discussion, Terrie was opening up the possibility of alternatives to the presentation of evolution based on the biology standards.

I classified Garrett as a theistic evolutionist on Scott's (2010) continuum. Garrett did not devote class time to a discussion where "everybody's sharing their ideas because those ideas aren't going to be on the state test." Garrett was very aware of the time constraints on teaching all the biology standards required for his class. The most important reason Garrett did not open up evolution to a class discussion was, "I feel like if we did have a discussion or a debate, it would undermine the content. It would undermine my lessons. Even just opening it up for debate undermines the lessons and so, no, I've never, never, done that." Garrett realized that in society at large the teaching of evolution is a debate and is controversial. However, he said,

> Within the scientific community it's not. It's settled science. And my job as a science teacher is to teach them the science, you know. That's what I'm here to do, and so I don't have any, I don't feel guilty, or like I'm doing them a disservice by just focusing on the science, you know, and ignoring those larger issues. Even though I myself am very familiar with the larger

> issues, and I know they come in with questions, I choose to ignore it in class.

Although he had deep religious convictions, Garrett felt his job was to teach the science, and not to have students learn to be debaters or attorneys on opposite sides of an issue. He believed he had a straightforward mandate to teach in a scientifically rigorous way.

Barbara occupied an extreme position on the religious/philosophical spectrum (Scott, 2010). Barbara was a materialist evolutionist and an avowed atheist. When asked about how she approached the teaching of evolution, instead of describing lesson plans, resources, and labs, Barbara's immediate response concerned her students' inquiries into her personal beliefs,

> When you teach evolution, and you say that word, the first thing they ask is, do you believe in God? And so my tactic is to never answer that question. And so, I keep them guessing. And some kids are very persistent. Yeah, I just made that conscious decision to make it a mystery.

Barbara felt her personal views made her vulnerable on the subject of teaching evolution. Barbara approached teaching evolution with caution. She said,

> I've had students say evolution is awful and I'm not going to learn that. I show them the standards, and I say I'm not going to deviate from this. And does it say anything about man and monkey, and they'll say no, all right, so are you ok with that? Yes. And then, we'll move on.

Barbara's teaching of evolution topics was bounded and justified by the educational standards associated with her course. She did not deviate from the standards because Barbara was fearful of the backlash if the conservative religious community in which she

taught discovered her personal beliefs, and she feared for her job security. Barbara had witnessed the firing of an atheist colleague who was forceful in his condemnation of students who did not accept the scientific viewpoint of evolution. Barbara's atheism influenced her close adherence to standards and her fear of losing her job. Barbara's pedagogical decisions were influenced by her perception of the conservative religious viewpoints of the community in which she taught.

Lily occupied the opposite end of the philosophical/religious continuum in this study. Lily described herself as a 24-7 young Earth creationist. Her personal views placed her in conflict with the scientific view of evolution. She said,

> People are oftentimes asking me, like, goodness, how can you teach evolution? Well, I teach evolution because it's part of the biological sciences. It is what it is. So despite that my own personal beliefs are in direct contradiction to what most biological scientists would agree with, subscribe to, it can be kind of challenging, but that at the same time, it is a basis, a foundation, for all the biological sciences, and so, I teach it the way that I'm supposed to.

However, later in our interview, Lily expressed her internal response this way. "In my head, as I'm teaching it, many times I'm like, what? Like, I don't like this, this is crazy. Like this is ridiculous, you know."

Both teachers demonstrated conflict in their teaching related to their strongly held religious/philosophical views. Although the two teachers held vastly different viewpoints, the result was the same. Both teachers made pedagogical decisions concerning the

manner in which they taught evolution based on the contradiction in their personal worldviews and their professional obligations.

Chapter Summary

Research questions for this study guided the collection, presentation, and analysis of data presented in this chapter. Research questions were: (1) How do teachers describe their preparation for teaching evolution? (2) How do teachers describe their teaching of evolution in secondary schools? (3) How do teachers describe the institutional and sociocultural influences that affect teachers' decisions about what and how to teach evolution?

Findings in this study were gleaned from interviews of fifteen Georgia science teachers conducted in April, May, and June of 2015 by the author. Since these 15 teachers were public school teachers in the state of Georgia, their classes were governed by educational standards defined primarily by the Georgia Performance Standards (2006, 2009). Nine of the fifteen teachers were high school teachers. High school teachers in this study taught subjects as diverse as Biology, AP and IB Biology, Environmental Science, AP Environmental Science, Human Anatomy and Physiology, and Zoology. Each high school course had a unique set of Georgia Performance Standards. Advanced Placement (AP) and International Baccalaureate (IB) programs imposed additional requirements on high school courses. Five of the teachers taught life science, which also had its own set of Georgia Performance Standards, to 7th grade middle school students.

This chapter provided narrative sketches of the fifteen Georgia teachers who participated in this study, followed by findings organized by analysis of data into themes related to each research question.

CHAPTER 5

DISCUSSION

Why is the teaching of evolution different from other topics in biology? Imagine yourself as a biology teacher considering how you will teach the topic of cell division. Would you wonder how your principal might react to your teaching? Would you expect a student to get up from his seat and walk from the classroom because he had religious objections to cell division? Would you expect your colleagues to question your personal beliefs about cell division? The topic of evolution is controversial for many, primarily because of philosophical and religious objections. In this section, I examine some of the factors and themes that emerged in this study and how my findings compare to those of other researchers. This discussion includes the influences of educational standards, standardized testing, teachers' experience teaching science, sociocultural factors, and teachers' worldviews. I conclude with implications of this study and recommendations for further research.

Purpose, Research Questions, and Methods

The purpose of this study was to understand teachers' experiences and beliefs of teaching evolution within the context of public schooling in Georgia. In support of the purpose of this study, I attempted to answer the following questions: (1) How do teachers describe their preparation for teaching evolution? (2) How do teachers describe their teaching of evolution in secondary school? (3) How do teachers describe the institutional and sociocultural influences that affect teachers' decisions about what and how to teach evolution?

I used interviewing as the primary source of data generation for this interpretive study of teaching evolution in public secondary school science classrooms. Fifteen secondary science public school teachers from the state of Georgia were interviewed for this study. These teachers represented 11 schools and 5 school systems. All interviews were conducted, recorded and transcribed by the researcher. Interview data were subsequently coded, and themes were developed. This discussion is organized by themes related to the teaching of evolution in the literature and the comparison of those themes to the findings of this study. Significant differences in findings are discussed for each theme.

Teacher Knowledge of Content Standards

Berkman and Plutzer's (2010) nationwide investigation of teachers' knowledge of biology content standards demonstrated teachers were not always aware of what they were supposed to be teaching in the classroom. These authors' study suggested there is little consensus among teachers even in the same state about exactly what is included in the standards. At least two studies show this may not be the case in Georgia. In a quantitative study of Georgia public school teachers, Nye (2014) found state standards influenced the teaching of evolution. Teachers in the qualitative study reported here were generally familiar with the content of evolution standards for the state of Georgia. A number of the biology teachers in this study specifically mentioned, "teaching the standards." Garrett, for example, referenced a standard for evolution, which he was able to quote verbatim from the standards document. He also expressed his opinion about how the standard was worded. He noted, "Students will evaluate the role of natural

selection in the development of evolution theory, which is a terrible way to word a standard like that."

Several other teachers referenced biology standards. Barbara noted how Georgia standards lacked mention of human evolution, "Human evolution? Right, the standard doesn't have human evolution in it. And it's kind of vague. Like some can interpret it to talk about humans." Mary admonished her students on being expected to know about evolution for college. She said, "This is in our standards for Georgia. You're expected to know this to go to college. Any college that takes you is going to expect you to have a basic knowledge in this topic. No matter what your major is." Joseph demonstrated awareness of the content of the standards for 7th grade Life Science, "I have to teach what the Georgia standards say I have to teach." June, who taught Zoology, had the Georgia standards posted on the wall above her white board and made frequent reference to them during instruction. This specific knowledge of the Georgia content standards for public school was clearly apparent for most of the teacher participants in this study.

Effect of Standardized Testing on Teaching Standards

Berkman and Plutzer (2010) maintained the lack of adherence to state standards on evolution by teachers was connected to the difficulty of imposing monitoring and sanctions on teachers who did not comply with teaching the standards. These authors pointed out standardized statewide student testing was the stick meant to enforce the teaching of the standards. They also asserted standardized testing in science alone had never become the high stakes testing that would trigger failure to graduate, failure to be promoted to the next grade, or the imposition of sanctions on a school or school system.

Science standardized testing in Georgia has never been high stakes. Until the 2014-2015 school year in Georgia, a student who failed a statewide graduation test known as the Georgia High School Graduation Test (GHSGT) would not graduate. This test covered all core subjects, and, although students could attempt it multiple times, failure would result in no high school diploma. However, as Berkman and Plutzer (2010) noted, and as was true for the Georgia test, it is the test as a whole and not a test of particular standards that may trigger consequences for schools, school systems, or individuals. Specific standards, like those covering evolution, are subsumed in the overall test outcome. However, the GHSGT was discontinued for school year 2014-2015, and a similar test is unlikely to take its place. Sanctions arising from this type of comprehensive test will probably not be used to enforce teachers' teaching of standards for any subject.

Standardized tests for individual courses were also replaced in Georgia during the 2014-2015 school year. For a number of years, Georgia has used individual standardized tests for specific courses, including courses with evolution standards. During the 2014-2015 school year, Georgia changed the entire suite of end-of-year and end-of-course standardized tests for its students. The new tests were called Georgia Milestones Assessments. However, the state announced early in the school year that the results of the tests would not count for the transition year. In addition, Georgia's new teacher evaluation system was to include the use of results of these tests to count for up to half of teachers' evaluations. That requirement was also waived for the 2014-2015 school year.

The testing situation for high school and middle school had some important differences. The new Milestones test for high school Biology was to count as the final

exam and scores on the test were to account for 20% of the final grade for the course. Students must have a score of 70% overall in order for the course to count toward one of the four Georgia graduation credits in science. Biology is a required course for all Georgia high school students, and its end of course test is meant to be a high stakes test for graduation from high school. However, because 70% is considering a passing grade, failing the end of course assessment does not mean failing the course, however unlikely that scenario may appear.

The standardized testing situation in middle school in Georgia was and will continue to be less consequential than that for high school. The new Georgia Milestones test for 7th grade life science will not determine whether a student passed the course or even passed to the next grade level. However, passing standardized tests in science have never counted in Georgia for passing to the next grade in middle school. Mathematics and reading standardized tests have been used to determine promotion to the next grade level. However, local school systems had the authority to promote students in spite of their standardized test scores on a case-by-case basis.

Although scores on both high school and middle school standardized tests did not count for the 2014-2015 school year, it is generally expected they will count in subsequent years. Passing test scores are important to the school because scores are factored into the school's performance for making Adequate Yearly Progress (AYP) under the No Child Left Behind (NCLB) Law.

Georgia teachers in this study seemed mindful of the standardized tests, but not overly concerned. High school biology teacher, Garrett, explained, "I try to get to as much as I can. You never know what's going to be on the state test at the end of the

semester." Garrett also believed doing well on the state required standardized tests was important to school administrators. Asked about administrative support for teaching evolution, he said, "Our administrators want high test scores on the state tests." Another high school teacher, Mary, explained, "This is the problem though. We teach, of course, all about the test now, you know, No Child Left Behind, everything's about the test, and test success." Mary taught classes that were considered "on level," and her biology students often struggled with the content. She said, "The problem is the on-level students who are coming from the Title 1 feeder schools, who, if their reading is low, everything is low. And their success is so important on that test, unfortunately. And I've learned that it's a numbers game." Mary was concerned about the students who struggled in high school regardless of the course. She emphasized in her teaching what she knew would be represented most on the test. And although Mary taught biology with a focus on evolution, she was always aware of the percentage of evolution questions on the test and thus, evolution's relative importance to the standardized test.

Number of Years of Teaching Experience and its Influence on Teaching Evolution

Another reason suggested to account for whether state standards would be implemented by individual teachers had to do with individual characteristics of teachers (Berkman and Plutzer, 2010). One of those individual characteristics was teacher experience. Berkman and Plutzer suggested teachers who had less than 10 years experience spent the most time teaching evolution. In this study, there were five teachers with less than 10 years experience. Of the five teachers, all reported teaching evolution in a scientifically accurate manner. Of the ten teachers in this study who had more than 10 years of teaching experience, not all taught evolution with scientific rigor. Berkman

and Plutzer (2010) suggested multiple reasons that a teacher with high seniority may not embrace standards. These reasons included investment of time and effort in existing lesson plans, being professionally socialized in a different era, and having tenure, which provides a buffer from administrative pressures.

I did not investigate all the parameters in this qualitative study as Berkman and Plutzer's (2010) quantitative study. However, in Georgia, teachers having tenure may not be as important a factor as in other states. Georgia has "Right to Work" laws, which restrict the existence of teacher unions in Georgia. Public school teacher tenure is not defined the same way in Georgia as teacher tenure in states that have teacher unions, nor as tenure is defined in university faculties. In Georgia, once a teacher has signed a fourth consecutive contract with the same school system, the teacher is said to have tenure. Having tenure from that point simply means that the teacher can expect to have continuous employment with that system unless "good cause" is shown for non-renewal. "Good cause" includes incompetency, insubordination, and immorality, among others. The weak status of tenure in Georgia may not be much protection to a teacher who defied an administrator's direct instructions not to teach evolution. The law concerning tenure in Georgia does guarantee the tenured teacher a full description of the charges and a right to a hearing. A hearing panel would probably dismiss a move to remove a teacher just for teaching evolution, but attempting such a removal is not out of the realm of possibility in a conservative, Bible Belt state such as Georgia.

In this study, one teacher described her experience of not being supported by her principal in her teaching of evolution. A second teacher described her experience of becoming fearful about teaching evolution after witnessing a colleague being fired

because of his position on teaching evolution. Catherine, a National Board Certified Teacher with 20 years of teaching experience, described being summoned to her principal's office to discuss a student's complaints about her teaching of evolution. She explained,

> Our principal called me up to the office about teaching evolution. He's like, you're not respecting their religious beliefs. Which I said there's no room for, it's not religion, that's in a private school. And so if you want it to be a religion class, you would chose to go to a school that provided you with religion classes. And this is public school, and we're just going with the science here. And there was a kid who didn't like that, and went up to the office, and he, I don't know what he said. I know that my principal called me up, and I'm like, are you kidding me? He said, well, you know. I felt like he was telling me just don't do it. Don't teach it at all. I said, it's part of the curriculum.

Although Catherine received her contract for the following school year, she chose to take a high school teaching job in another school system nearby. The experience of not being supported in her teaching forced her decision to remove herself from what she perceived to be harassment on the part of this administrator.

The other high school teacher, Barbara, also feared not feeling supported by her administrator. Barbara witnessed the firing of a colleague over his militant stance in teaching evolution. After that incident, she became more cautious in her approach to teaching evolution and did not teach human evolution at all.

Sociocultural Factors and Teaching Evolution

Sociocultural factors influence teachers and are enacted through their pedagogical decisions concerning the teaching of evolution. There are numerous sociocultural reasons evolution may not be taught in public school biology classrooms. If teaching evolution is downplayed, deemphasized, or ignored, the teacher has made a pedagogical decision. First, the teacher's reason for avoidance may be based on her own belief or acceptance of evolution. Secondly, her pedagogical decision could be based on what she perceives to be her students' belief or acceptance of evolution. Thirdly, her reason could be based on what she perceives to be the broader community's perspective on the teaching of evolution. The broader community could potentially include school or central office administration, the school board, parents, or other stakeholders. Research revealed all of these reasons might play a role, either singly or in combination, in teachers' pedagogical decisions (Berkman et al., 2008; Berkman & Plutzer, 2010; Goldston & Kyzer, 2009; Griffith & Brem, 2004; Hermann, 2013; Koevering & Stiehl, 1989; Moore & Kraemer, 2005; Nye, 2014; Osif, 1997; Rutledge & Mitchell, 2002; Rutledge & Warden, 2000; Tatina, 1989).

In this study, the most commonly evident reason evolution was not taught is the perceived conflict between personal beliefs of the teacher and the concept of evolution. One high school teacher, Lily, self-identified as a 24-7 creationist, but insisted that she taught evolution standards as they should be taught. She explained, "…despite that my own personal beliefs are in direct contradiction to what most biological scientists would agree with or subscribe to, it can be kind of challenging. But at the same time, it is a basis, a foundation, for all the biological sciences, and so, I teach it the way that I'm

supposed to. The way that, you know, I think, most other teachers would." Lily's use of open discussion of alternatives to a strict scientific interpretation of evolution belied her insistence on being able to push aside her personal convictions. As an introduction to the topic of evolution, Lily invited her students to consider "there are lots of potential ideas out there, and it is the students' responsibility to research all of those ideas, and come to their own conclusions." Her open invitation to students' investigation of all sides of the question of evolution demonstrated her personal beliefs reflected in her pedagogy. She said, "I just want their minds to be opened to anything, and I just usually kind of describe it like, if I am a defense attorney, then I need to know the opposing viewpoint." Lily revealed in her interview, that if asked, she could speak knowledgeably about creationism.

Lily's stance on researching the "potential ideas out there" is reminiscent of the "Academic Freedom" laws that resulted from the Santorum Amendment, introduced by former Pennsylvania U.S. Senator Rick Santorum. This amendment was submitted to the No Child Left Behind Act in 2001, and passed the Senate, but the language was stricken from the final bill. Subsequently, identical language appeared in a number of "Academic Freedom" bills, which were introduced in state legislatures beginning in the early 2000's. The Santorum Amendment read,

> The Conferees recognize that a quality science education should prepare students to distinguish the data and testable theories of science from religious or philosophical claims that are made in the name of science. Where topics are taught that may generate controversy (such as biological evolution), the curriculum should help students to understand the full range of scientific views that exist, why such topics may generate

controversy, and how scientific discoveries can profoundly affect society. This amendment singled out evolution as a controversial subject, and the language was associated with the Intelligent Design movement. Perhaps Lily's open discussion of alternative ideas and the language in the Santorum Amendment came from a similar source.

Another teacher, Terrie, had a similar "open minded" approach to teaching, Terrie talked with students about her own religious beliefs and how the appearance of life on Earth coincided with her interpretation of the Bible. She stated, "In the Bible, in Genesis, it talks about it (the Earth) was created over a period of time. To me, it kind of matches up with a lot of what I understand in biology." Terrie claimed her open discussion method was not designed to change students' personal views about evolution. She explained, "I'm not trying to change anything, I just want you to get a, have an appreciation for the subject. You don't have to believe it. It's just, you're just hearing it… One of the things that I say to my students is respect everybody's opinions." Terrie welcomed discussion of religious beliefs of her students and how those beliefs were integrated with the concept of evolution.

Although both Lily and Terrie presented evolution in their biology classes, they wanted their students to be open to alternatives. These teachers' pedagogical decisions were similar to those reported in quantitative studies of public school teachers in Wisconsin (Koevering and Stiehl, 1989), South Dakota (Tatina, 1989), Pennsylvania (Osif, 1997), Indiana (Rutledge and Mitchell, 2002), Minnesota (Moore and Kraemer, 2005), Florida (Fowler and Meisels, 2010) and Georgia (Nye, 2014). In a qualitative study of fifteen public school teachers in Arizona, Griffith and Brem (2004) conducted a

study of the teachers' experiences in teaching evolution. Fifteen teachers from the Phoenix, Arizona area were interviewed either one-on-one or in focus groups. The results of this study led the authors to classify their respondents as "scientists, selective, or conflicted." The selective teachers had a wide range of pedagogical approaches. One of the selective teachers was a creationist who did not teach evolution at all. Another selective teacher did not allow discussion, used lecture only, and did not even use the word evolution until well into the unit. It is interesting to note this particular selective teacher from the Arizona study had a different motive for not allowing discussion than one of the teachers in the current study. Garrett did not allow whole class discussion because he felt it would undermine the content on evolution. He thought discussion would seem to make the concept of evolution debatable.

Other sociocultural factors that might influence the teaching of evolution are the teachers' perceptions of beliefs about evolution held by stakeholders in the community. In this study, I considered stakeholders to mean students, parents, administrators, and the wider school community. Griffith and Brem (2004) identified a group of Arizona teachers in their qualitative study whom they classified as "conflicted." Conflicted teachers felt stress because they struggled with their own beliefs and worried about the possible impact of their teaching on their students, but felt that they must teach evolution. In this study, Garrett worried about his students' beliefs, but that stress did not prevent him from teaching evolution. He explained, "My job as a science teacher is to teach them the science. Even though I myself am very familiar with the larger issues, and I know they come in with questions, I choose to ignore it in class." In spite of this straightforward approach to the teaching of evolution, Garrett felt his own religious

beliefs were an advantage to him. He explained, "I myself, and I think this is a benefit; I myself am a deacon in a Baptist church, in a southern Baptist church, a Sunday school teacher. Most of the people that I associate with most of the time are like that kid (who turned in blank papers for his assignments on evolution). And so the reason I think that's a benefit is because like with that, when that boy turned in those papers, I really understood that." Garrett used his familiarity with his own religious beliefs to help him understand how a student with a similar background would respond to his teaching about evolution.

In Goldston and Kyzer's (2009) case study of three Alabama public school teachers, two of the three teachers studied did emphasize evolution in their classes. However, their pedagogy changed to a more cautionary approach compared to other noncontroversial topics that they taught during the school year. Some teachers in the present study exercised caution as well. Barbara, a high school biology teacher, identified herself as an atheist. She witnessed the firing of one of her colleagues who was also an atheist. Her colleague had been confrontational with students and parents in his support of evolution. He was fired in the middle of the school year. Barbara's response was "You can't act like that. If your customers aren't happy, you're not doing what you're supposed to be doing. Teach the standards." Barbara was cautious about teaching evolution since she had seen her colleague lose his job. She explained how her teaching had changed since the incident.

> …it sounds like I'm kind of dumbing down or trying to circumvent this topic that's very important, but there are bigger powers that be than myself,

so, learning from his experience, witnessing it first hand, as a colleague, so I just try to keep my head down.

Keelin, a middle school science teacher, was acutely aware of her constituencies. She had a Bachelor's degree in biology and excellent content preparation for teaching evolution. Although she taught about natural selection and adaptations, she rarely used the word "evolution" in her teaching. She explained, "I haven't had a direct challenge. My only challenge is I guess not feeling confident enough to really showcase it (evolution)." She was concerned about the different religious backgrounds of her students and families and how they might respond to the teaching of evolution. She said she was always nervous during the annual PTA curriculum meeting for parents when she explained about the various units that would be taught during the year. She wondered if anyone would ever object, but she had not had any questions from parents. She explained, "I would just like to teach it (evolution) better, but that's not because I feel a lack of preparedness, and then probably if we got more into it (evolution), then I would be a little bit more nervous, because of the different religions that we see (in class)." Although Keelin had never in four years of teaching life science experienced a direct challenge from students, parents, or anyone in the community, she was cautious in her approach to teaching evolution.

Evolution in the Courts and Teaching Evolution

Moore (2004) maintained, "Many public school teachers are misinformed about legal issues associated with the teaching of evolution." Although this study did not specifically address knowledge of legal issues surrounding the teaching of evolution, the influence of local (Georgia) legal issues on two teachers in this study is worth noting.

The two teachers who specifically mentioned legal issues surrounding teaching evolution were the two who expressed the most caution in their pedagogy. These two teachers had both moved to Georgia during the time of the court case of *Selman v. Cobb County School District* (2005). Coincidentally, both moved from Maine to Georgia. Barbara was a native of Texas, but she had been teaching in Maine before coming to Georgia. She had heard about the court case challenging the warning stickers on evolution placed in textbooks in Cobb County. She interviewed for a job in Georgia and got it. She remembered conversations with her colleagues in Maine about the court case before she knew she would be moving to Georgia. Barbara's colleagues did not understand why textbooks would need stickers warning students about teaching evolution. She explained, "Yeah, it was all the stickers in the books. They were reporting that, and I had no idea when I was watching that I would end up teaching in (a large metropolitan) County, so it was kind of strange to see it in the news." Barbara knew she was moving to a religiously conservative state with a potential for controversy over the teaching of evolution. Within 7 years, she witnessed a colleague's firing over his stance on teaching evolution. In order to preserve her job, she adopted a cautious stance on the teaching of evolution.

Keelin was also apprehensive about teaching evolution in Georgia. She was originally from Maine, and had lived in Pennsylvania and Vermont as well. She moved to Georgia before becoming a teacher. She heard about the *Selman v Cobb County School District* (2005) court case on the news. She explained, "My teacher preparation program was in Georgia, and that's when I was like, oh yeah; this (teaching evolution) is going to be potentially an issue. But then I started looking at this school system (where she currently teaches), and I thought, of all places, it's probably not going to be an issue

here." And yet, she was still cautious about the teaching of evolution. In this study, therefore, the two teachers who were probably most cautious in their approach to the teaching of evolution were also the two who specifically mentioned a well-known court case in the state concerning the teaching of evolution. Even though the result of *Selman v Cobb County School District* caused the removal of stickers from the textbooks, the notion that it could happen in Georgia was sufficient to cause these teachers to have a heightened awareness of the possible consequences of teaching evolution in a conservatively religious state. Because a number of studies have indicated that biology teachers are uninformed about legal issues surrounding the teaching of evolution, a follow up study on these perceptions might be revealing (Moore, 2004; Moore, 2002).

Worldviews and Teaching Evolution

Cobern (1996, p. 580) explained how the ideas of "force" and "scope" are important to an understanding of worldview theory. A concept or belief has force if it is central in an individual's thinking rather than marginal. A concept or belief has scope if it has relevance for the individual over a wide range of contexts. For example, Griffith and Brem (2004) identified one group of biology teachers as "conflicted." These were teachers who struggled with their own beliefs and the possible impact of those beliefs on their teaching. For these teachers, the conflict arose from the "force" or centrality of their personal views about the validity of evolution as an explanation for the diversity of life on Earth. Two of the teachers that Goldston and Kyzer (2009) studied were less willing to teach human evolution than the evolution of lower life forms because their students tended to view humans as special creations of God. The "force" and "scope" of their personal or their students' religious beliefs affected these teachers' practice.

In this study, Molly's personal beliefs were associated with her identification as a Protestant Christian. She spoke of giving a brief talk at her church about how her religious beliefs and her scientific training meshed. In her message, she showed photos of cells and current images from space. Molly's ideas centered around her belief in a supernatural power (God) that was responsible for the origin of the raw materials that were acted upon by natural forces in the process of natural selection. Molly had deeply held Christian beliefs that did not threaten her adherence to the scientific viewpoint of evolution. Both her religion and her scientific outlook had scope and force for Molly because they had relevance over a wide range of contexts and were central, in both her teaching and personal life.

Barbara's atheist worldview had a high degree of force or centrality in her enactment of teaching evolution. Barbara's college degree prepared her well to teach the scientific viewpoint of evolution. Her undergraduate degree was in biology with an emphasis in field biology. How did that thorough preparation translate into her classroom teaching? Barbara approached teaching evolution with caution. She said,

> I've had students say, you know, evolution is awful and I'm not going to learn that, and that's not what I learned at home and I, I tell them that, I show them the standards, and I say, I'm not going to deviate from this. And does it say anything about man and monkey, and they'll say no, and then, all right, so are you ok with that? Yes. And then we'll move on.

Barbara's teaching of evolution topics was bounded by the educational standards associated with her course. She did not deviate because the standards were her fallback justification for her instruction regarding evolution.

Both Barbara and Molly taught biology standards in their classes. Barbara and Molly's worldviews were in rigid contrast to each other. One had no belief in a supernatural being, while the other celebrated its existence. One limited her teaching of the evolution standards to the extent that it did not call overt attention from any of her constituents. The other went beyond the standards to teach human evolution, a topic not addressed in the Georgia standards at all, perhaps because of its potential for controversy. My findings here supported those of Berkman and Plutzer, who found in their nationwide quantitative study of public high school biology teachers that "not only do personal beliefs influence instruction, they also have a stronger impact than any other factor we have examined" (2010, p. 186).

Conclusions and Recommendations

The theory of evolution is a unifying theme in biology (Dobzhansky, 1973). A number of well-respected national scientific and educational professional organizations recognized the importance of including a rigorous treatment of evolution as the foundation of the study of biology. However, many teachers, especially K-12 educators in the United States, do not provide this rigorous treatment. Why? There are many reasons, and just a little scratching of the surface reveals there are layers of complications. However, given the importance of the teaching of evolution to a deep understanding of biology, studying influences on teaching evolution at the secondary level is important.

This study supports the findings of other researchers (Berkman & Plutzer, 2010; Hermann, 2013; Griffith and Brem, 2004; Goldston and Kyzer, 2009; Smith, 2010) on why teachers do or do not teach evolution. There are easily identifiable institutional and sociocultural factors that influence the teaching of evolution. These factors may either

support or fail to support the teaching of evolution in a scientifically rigorous way. They include, but are not limited to, teacher college preparation programs, teachers' worldviews, national, state and local educational standards, student and parent religious beliefs, teacher colleagues' support of evolution, and school administration support.

Two major limitations of this study could be ameliorated by the inclusion of an expanded participant pool and the development of a case study. This study restricted the population of Georgia teachers studied to an urban/suburban area. Studying a similar population of teachers in a rural area might reveal different results. Such a study needs to be done for comparative purposes. A second limitation of this study has to do with methods. Although interview data provided a rich portrait of the diversity of approaches to the teaching of evolution being employed by Georgia teachers, the inclusion of observation and document data would be invaluable for triangulation of findings. The expansion of the participant pool as well as methods would provide a richer portrait of Georgia teachers' teaching of evolution.

A number of researchers have emphasized the importance of evolution education in pre-service teachers programs (Hermann, 2013; Smith, 2010; Rutledge and Mitchell, 2002; Rutledge and Warden, 2000). I agree with Smith's specific recommendation that such a class should include the study of evolution as content, but also misconceptions related to understanding evolution and a focus on the nature of science and dealing with controversial issues in science. Part of such a course should include Smith's (2010) recommendations from his reflections on teaching evolution. Smith encouraged teachers to be respectful of students. Smith asserted, "We may know more science than they do,

but we do not hold all the answers to the question of life. When they speak, listen. Try to understand what they are saying and why."

The experience of teaching evolution is affected by the institutional and sociocultural factors discussed above and the personal beliefs and capacities (the worldview) of the teacher. The institutional and sociocultural influences capture the context in which the teacher's responses to those influences operate. The challenges to teaching evolution are produced when the institutional and sociocultural influences and the teacher's worldview intersect.

This study revealed important findings, which could serve as a starting point for future research. This study provided evidence for the following conclusions. (1) Most teacher participants in this study were well prepared with respect to evolution content and pedagogy. (2) Teachers were generally familiar with the content of evolution standards. (3) Standardized testing on evolution was not a significant stressor for these Georgia teachers. (4) Teachers participants claimed a variety of religious/philosophical views of evolution, which influenced their pedagogical decisions. (5) Institutional and sociocultural factors that have influenced teachers in other parts of the United States also affect teachers in Georgia.

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