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Postsecondary Students' Perceptions Toward Accepting and Understanding Biological Evolution: A Qualitative Metasynthesis

Erin Childress
childresse@sfasu.edu

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POSTSECONDARY STUDENTS' PERCEPTIONS TOWARD ACCEPTING AND UNDERSTANDING BIOLOGICAL EVOLUTION: A QUALITATIVE METASYNTHESIS

by

Erin Fucik Childress, B.S., M.S.

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APPROVED:

_____
Karen Embry Jenlink, Ed.D., Dissertation Chair

_____
Patrick Jenlink, Ed.D., Committee Member

_____
Ali Hachem, Ph.D., Committee Member

_____
Josephine Taylor, Ph.D., Committee Member

_____
Gloria Gresham, Ed.D., Interim Chair, Department of Secondary Education and Educational Leadership

_____
Pauline M. Sampson, Ph.D.,
Dean of the Graduate School

ABSTRACT

The purpose of this qualitative meta-synthesis is the exploration and analysis of postsecondary students' perceptions towards accepting and understanding evolution. Evolution as a process and theory is a foundation for understanding the biological sciences. Within the scientific and educational communities, evolution is a central theme tying the fabric of the biological sciences together. A three-tiered analysis was used to determine postsecondary students' perceptions towards accepting and understanding evolution. This meta-synthesis analysis was guided by the following research questions: (1) What perceived conflicts do post-secondary students face when learning about evolution? and (2) Based on post-secondary students' perspectives, how do personal religious beliefs influence understanding and accepting evolution? Overarching themes that emerged from this study included students' perceived conflict between religion and evolution, students' views of evolution strengthen religious beliefs, students' religious beliefs and acceptance of evolution are kept separate from each other, evidentiary support is used to accept or deny evolution, exposure to evolution and scientific literacy influence acceptance of evolution, and the environment in which students learn evolution can influence their acceptance of evolution.

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CHAPTER I

Introduction to the Study

Introduction

As the world's population continues to grow, interactions between humans, animals, and the environment become topics to investigate as we move forward in an interconnected world. Issues of global food production, medical advances, disease spread, changing climate and conservation of natural areas are but a few concerns we as citizens will continue to face (Rice et al., 2015). These problems, and ones that are unforeseen, remain on the minds of civilians in our society, and will be issues that students we are currently educating will inherent. One of the topics that surrounds, and provides understanding, and potentially answers to these ever present matters, is evolution and the biological processes within (Heddy & Nadelson, 2013). The ability for students to understand and accept evolution is a positive measure for scientific development and growing support for science endeavors as students add their voices to scientific conversations (Miller et al., 2006). Examining science curriculum from primary education through higher education and how students perceive and understand evolution can allow us to better prepare students for the scientific decisions they will be making in a globally connected society. Both the American Association for the

Advancement of Science (AAAS) and the National Research Council highlighted the importance of teaching evolution in the classroom and emphasized evolution as a central and unifying theme in science (American Association of the Advancement of Science, 1990, 1993; National Research Council, 1996). The scientific community also holds strong persistent agreement that the topic of evolution is a central theme throughout many biological fields and is regarded as a vital part of science and science education (Nehm et al., 2009; Skoog, 2005; Quessada et al., 2008; Yates & Marek, 2014).

From this view, evolution as a process and theory is a foundation for understanding the biological sciences. Exploring what influences a students' acceptance and understanding of this topic is key to ensuring students are knowledgeable on the topic of evolution. Current studies have discussed issues influencing a students' understanding and/or acceptance of evolution; however, an overall synthesis of current studies related to postsecondary students' acceptance and understanding of evolution was not found in the review of the literature. This meta-synthesis study will focus on postsecondary students' perspectives towards accepting and understanding evolution.

Background of the Problem

Since the Scopes trial in 1925, attention to the controversy between evolution and creationism as it relates to teaching about evolution has fluctuated around the country (Hermann, 2008). The topic of evolution has been accepted as a central and foundational topic to every science-based curriculum, hence the inclusion of teaching evolution in science standards. Evolution has become a controversial topic that is diverted at the

expense of our students, resulting in misconceptions and weak understanding of the topic when the student enters a postsecondary school. Hermann (2008) states,

> Schools in this country could serve as key platforms of engaging young people's interest in evolution as well as addressing misconceptions about evolution. Instead, they have become battlegrounds on which the public acceptance of the theory of evolution and the veracity of the science of human evolution in particular is being fought, with teachers on the front line (p.239).

Within secondary and postsecondary science education, students have struggled with accepting and understanding evolution and its context in a variety of natural systems (Alters & Nelson, 2002; Demastes et al., 1995; Glaze et al., 2015). Students' difficulty understanding evolution has been associated with discord of practice of science (NOS) views (Borgerding et al., 2017). Acceptance of evolution has also been linked to understanding the topic. However, the relationship between acceptance of evolution and understanding evolution vary throughout current literature (Borgerding et al., 2017). Some studies have shown a strong relationship between evolution understanding and acceptance, some a weak relationship, and other studies found no relationship between the two (Boregerding et al., 2017).

While an individual's belief system could be a predictor toward understanding evolution, some studies show that students can understand the topic of evolution without believing in the theories that explain biological patterns and mechanisms surrounding the evolutionary process. Sinatra et al. (2003) expressed that "students may have an understanding of evolutionary theory without accepting its validity, or alternatively, they

may accept the validity of the construct based upon a poor understanding of it" (p. 521). Bishop and Anderson (1990) concluded that students' "conceptions of the process of evolutionary change were not associated with their belief (or lack of belief) in the truthfulness of evolution" (p. 425) based on the pre- and post-test scores of 110 college students in an introductory biology course which discusses evolution.

Instructors play a role in the construction of students understanding of evolution as a central unifying theme to science (Brem et al., 2003). Dialogues concerning the influence of instructors that strongly support and teach evolution abound, as well as those that ignore the subject or include other nonscientific alternatives (Berkman & Plutzer, 2011). According to Berkman and Plutzer (2011), "A teacher's personal belief concerning human origins is a powerful predictor of her classroom behavior, as is her prior completion of the semester-long course on evolution" (p. 625). Teachers' perception of their ability to teach evolution also influences the amount of exposure to evolution, and related topics, students will receive (Aguillard, 1999).

The misconceptions, lack of understanding and/or unwillingness to accept evolution extend from the classroom to the general public, particularly concerning human evolution (Alters & Nelson, 2002, Miller et al., 2006). According to Miller et al. (2006), 78% of adults from the United States, from a sample of 1,484 individuals, agreed to the definition of evolution of plants and animals, if the word 'evolution' was omitted from the question. Of those 1,484 adults, 62% in the same study believed that humans were created as "whole persons without evolutionary development" (Miller et al., 2006). Gallup polls addressing acceptance of evolution have run since 1982 with little change in

responses (Pobiner, 2016). Between 31% and 40% of individuals taking the poll believe that humans have developed over millions of years, but the process was guided by God (Pobiner, 2016). The percentage of individuals that believe humans have developed over millions of years without the influence of God was between 9% and 19% during this time (Pobiner, 2016), while between 40% and 47% of individuals believed that God created humans in their present form within the last 10,000 years (Pobiner, 2016).

Within the scientific community, evolution is a central theme tying the fabric of the biological sciences together. Lack of acceptance and understanding in evolution is seen as a curricular failure impacting students interested in a STEM degree who will compete for 21st-Century jobs (Pobiner, 2016). The importance of understanding evolution by students is mirrored in the inclusion of evolutionary theory in national standards, both recently in the Next Generation Science Standards (NGSS) and in past national standards like the National Science Education Standards (NSES) (NGSS Lead States, 2013). Understanding evolution will empower and inform our students when participating in elections, referendums on environmental and health care issues, and other societal problems (Pobiner, 2016).

Statement of the Problem

A students' acceptance and understanding of evolution will provide the framework for answering questions related to a wide range of phenomena, such as vaccines, medicine, biotechnology, genomics, agriculture, conservation, and climate change. Students are entering postsecondary schools with misconceptions about evolution that could impact their ability to understand scientific explanations presented in

class (Cunningham & Wescott, 2009). These misconceptions are strong enough to have persisted through primary and secondary school, either having been self-constructed or taught/learned through experiences (Cunningham & Wescott, 2009; Sinclair et al., 1997).

Singular studies concerning students' acceptance and understanding of evolution provide a small window for deciphering the larger question of perceptions students hold that influence acceptance and knowledge on the subject of evolution. A students' understanding of evolution has been linked to their acceptance of the topic, amount of exposure and/or presentation of the topic from a teacher, the students' worldview and belief systems, and harboring misconceptions about evolution (Berkman & Plutzer, 2011; Hermann, 2008; Pobiner, 2016). For example, Sinatra et al. (2003) researched 93 undergraduate participants, who were not STEM majors, with the goal of examining the students understanding and acceptance of evolution and their epistemological beliefs and cognitive dispositions. Sinatra et al. (2003) highlighted further investigation based on three findings within their research, which included: (1) no evidence of a relationship between acceptance of evolution and understanding of evolution; (2) evidence that epistemological beliefs and cognitive dispositions were related to the acceptance of human evolution; (3) variation in the interaction between epistemological views, dispositions, understanding, and acceptance of evolution based on the controversy of the topic being considered. In other studies, logical and critical thinking skills were also found to enhance a students' ability to understand and accept evolution (Alters & Nelson, 2002; Lawson & Weser, 1990; Pigliucci, 2007 and Woods & Scharmann, 2001).

After questioning 218 students taking an introductory college zoology course, Sinclair et al. (1997) concluded, “students’ beliefs can interfere with their ability to view scientific evidence” (p. 123). Other studies have focused on non-academic factors, such as religious beliefs (Brown, 2015; Borgerding et al., 2017; Glaze et al., 2015 and Rice et al., 2011), and how belief systems affect a student’s acceptance and understanding of evolution.

Current studies related to understanding and/or acceptance of evolution provide many pieces to the overall student experience of learning evolution; however, an overall synthesis and analysis of the studies was not found in a review of the literature. The focus of this qualitative meta-synthesis will be on postsecondary students’ perspectives towards accepting and understanding evolution.

Purpose and Research Questions

The purpose of this qualitative meta-synthesis is to explore and analyze postsecondary students’ perspectives towards accepting and understanding evolution. The studies used will be qualitative in methodology and a qualitative approach to the meta-synthesis of the studies will be incorporated in this study. The aim of a qualitative meta-synthesis is to develop “an explanatory theory or model which could explain the findings of a group of similar qualitative studies” (Walsh & Downe, 2005, p. 204). This study will focus on postsecondary students’ perspectives toward acceptance and understanding of evolution and perceived factors that influenced the students’ acceptance and knowledge of evolution up to this point in their educational careers.

This exploratory qualitative meta-synthesis will be guided by the following questions:

1. What perceived conflicts do post-secondary students face when learning about evolution?
2. Based on post-secondary students' perspectives, how do personal religious beliefs influence understanding and accepting evolution?

Definition of Terms

Because some definitions may be unfamiliar to the reader, conceptual definitions are included for reference.

Acceptance (of evolution).

Acceptance is defined as "a personal assessment of the validity of a construct [evolution] based on an evaluation of evidence" (Wiles, 2008. P. 21).

Belief.

Belief as used for evolution is defined as "the recognition of a theory's validity using personal conviction, opinion, and extrarational criteria" (Nehm & Schonfeld, 2007, p.718).

Creationism.

Creationism is defined as "the finding of order, purpose, and design in the world is proof of an omniscient designer" (Scott, 2004, p. 52). Other terms used instead of creationism have been creation-science, and intelligent design (Forrest, 2018).

Creation-Science.

Creation-science refers to “the movement of Christian fundamentalists based upon an extremely literal interpretation of the Bible” (Beckwith, 2003, p. 460)

Evolution.

Evolution is defined as “the scientific principle that the diversity of life on Earth has arisen via decent with modification from a common ancestry” (Scott, 2004, p. 230).

Biological Evolution Theory.

For this study, biological evolution theory is defined as a theory that helps us understand the enormity of biological diversity on Earth from one common ancestor via a wide range of observations, accurate predictions, and thousands of experimental and observational studies (Rice, 2012).

Knowledge.

For this study, to qualify as knowledge, “a proposition must be thought to have some sort of correspondence to reality and the learner must have valid reasons that justify her acceptance of that proposition (justifications such as an objective, rational appraisal of supporting claims)” (Sinatra et al., 2003, p. 511).

Natural Selection.

Natural selection is defined as “the engine by which species adapt, survive, acquire new characteristics, and pass them on to their offspring” (Beckwith, 2003, p. 462).

Nature of science.

Nature of science is defined as "the ways in which scientific knowledge is generated, validated, and recognized by society as legitimate" (DiGiuseppe, 2014, p. 1062).

Scientific literacy.

Scientific literacy is defined as "what the public should know about science in order to live more effectively with respect to the natural world" (Deboer, 2000, p. 594).

Theistic Evolution.

Theistic evolution is defined as "the theological view that God creates through evolution" (Scott, 2004, p. 53).

Theory.

Theory is defined as "a well-substantiated explanation of some aspect of the natural world that can incorporate facts, laws, inferences, and tested hypotheses" (National Academy of Sciences, 1998).

Significance of the Study

Evolution is widely accepted as the underlying framework of science. The understanding and acceptance of evolution unifies many of the scientific topics within the discipline of biology, such as cell biology, anatomy and physiology, genetics, molecular biology, ecology, animal behavior, and pathogenesis (Rutledge & Mitchell, 2002). Understanding evolution provides the framework for answering scientific questions and increases students' ability to thrive in a world that needs science to solve large scale

problems, and live in communities that need supporters of current scientific undertakings (Miller et al., 2006). Examining students' acceptance and understanding of evolution may provide instructors and curriculum specialists information to evaluate and refine educational strategies that espouse an increase in scientific literacy. Examining the acceptance and understanding of evolution in postsecondary students could also provide educators with more information to embrace discussions of evolution in the context of current scientific problems, and lead to promotion of evolution curriculum earlier in a students' scientific education.

The inclusion of evolution today in many state and national standards emphasizes the importance of students understanding of the topic of evolution. However, there continues to be variations from state to state concerning science standards (Glaze & Goldston, 2015). Students enrolled in college level courses have misconceptions or a lack of understanding of the mechanisms of evolution (Sinclair et al., 1997). Examining the barriers that students face in accepting and understanding evolution can provide secondary and postsecondary science instructors with an increased knowledge that can be used to address a student's ability to understand the topic of evolution.

Although there are many studies exploring various populations of students and their understanding and acceptance of evolution, there are no qualitative syntheses of studies that deal specifically with post-secondary students' perspectives towards accepting and learning evolution. The goal of this qualitative meta-synthesis will be the exploration and analysis of postsecondary students' perspectives of accepting and understanding evolution within current literature. Educators and policy makers may

utilize this study to support their students' continued interest in the biological sciences throughout their academic careers.

Organization of the Study

This qualitative meta-synthesis study explored and analyzed postsecondary students' perspectives of accepting and understanding evolution within current literature. This study is organized into five chapters. The first chapter introduced the background of the problem, the statement of the problem, purpose of the study, the research questions, significance, and the organization of the study. Chapter II synthesized the literature related to the history of evolution in public schools and science curriculum. Chapter III described the methodology, the design of the qualitative meta-synthesis, the role of the researcher, data collection and analysis, and provisions of trustworthiness. Chapter IV described the findings of the study. Chapter V interpreted the findings of the study and provided implications for future research.

CHAPTER II

Review of Literature

Introduction

This chapter provided the background in which this study analyzed post-secondary students' perspectives of accepting and understanding evolution. Contextualizing terms related to evolution are presented in this chapter to provide the reader with a framework in which this study is positioned. Current and relevant literature associated with biological evolution and the information surrounding this topic is highlighted within this chapter. Chapter two presented the history and controversy of evolution in textbooks and the history of court cases involving evolution and teachers' willingness to teach evolution in light of the topic being considered controversial. Lastly, this chapter highlights the relationship between a student's personal beliefs and the acceptance of evolution.

Defining a Theory

The definition of a theory, within scientific textbooks, varies depending on the publisher, subject, grade level, and what curricular standards were adopted during the creation of a particular book. When examining science textbooks, a theory is assumed to be defined within a scientific context, which can be different than how the general

population uses the term. Theory in a colloquial use can be confused with a "hypothesis" in scientific terms. Within the sphere of the scientific method, the "most successful hypotheses are the ones that make specific predictions confirmed by large numbers of empirical tests" (Hickman et al., 2001, p. 11). Hickman et al. (2001) stated, "If a hypothesis is very powerful in explaining a wide variety of related phenomena, it attains the status of a theory" (p. 11). The information defining a theory according to Campbell et al. (1999) parallels Hickman et al.'s (2001) statements. Campbell et al. (1999) advanced farther in stating that "a unifying theory does not become widely accepted in science unless its predictions stand up to thorough and continual testing by experiments and observations" (p. 426).

The term theory can also be misused when it is compared and used as the opposite of a fact.

> The differences between fact and theory are described by Krupa (2015) as,
>
> A *fact* is a scientific explanation that has been tested and confirmed so many times that there is no longer a compelling reason to keep testing it; a *theory* is a comprehensive explanation of some aspect of nature that is supported by a vast body of evidence generating testable and falsifiable predictions. (p. 4)

Examples that Krupa (2015) provided to describe the relationship between a fact and theory are, "the existence of pathogens as a fact; germ theory provides testable explanations concerning the nature of disease" or "the existence of cells is a fact, and cell theory provides testable explanations of how cells function" (p. 4). Fact and theory are

related to each other, which can cause confusion in how the terms are used. "Facts and theories are different things, not rungs in a hierarchy of increasing certainty. Facts are the world's data. Theories are structures of ideas that explain and interpret facts" (Gould, 1981, p. 35).

As Gould (1981) emphasized, "In science, 'fact' can only mean 'confirmed to such a degree that it would be perverse to withhold provisional assent" (p. 254). This statement can be illustrated by gravitational law, in which, apples may start to rise tomorrow; however, the possibility does not mean that physics classes will spend equal time discussing this possibility (Gould, 1981). It is important to state, "falsification of a specific hypothesis does not necessarily lead to rejection of the theory as a whole" (Hickman et al., 2001, p. 12). Many hypotheses are applied to test a single theory, and ask whether a theory is generally applicable (Hickman et al., 2001).

Evolutionary theory.

When defining the term theory, and using examples to illustrate the term, many times the discussion of Charles Darwin's thoughts on evolution is highlighted. "The view that facts and laws are absolute, whereas theories and hypotheses are tentative, is a widespread misconception" (Brickhouse et al., 2000, p. 355). Clarifying how fact, theory, and hypothesis apply to biological evolution is necessary for framing the following sections of this chapter. To reiterate, "a theory is more comprehensive than a hypothesis" (Campbell, 1999, p. 426), while a fact is a scientific explanation that has been tested and confirmed many times. For the scope of this study, evolution will be defined as a scientific explanation, while evolutionary theories (such as natural selection

or sexual selection) explain the biological patterns and mechanisms of that fact. Thus, "Darwin's theory of natural selection accounts for many facts and attempts to explain a great variety of phenomena" (Campbell, 1999, p. 426).

Another phrase that could be used during the examination of current literature is the expression "theory of evolution." This language had been used to discredit evolution as "just a theory" that has not been proven. It is important to examine how this language is framed in current literature and how each author contextualizes and presents their findings and thoughts about evolution.

Theory as it relates to this meta-synthesis.

Conceptualizing the meaning of a theory, specifically biological theories, will vary depending on many factors, including the topic of study, personal beliefs of an individual, and an individual's background knowledge of science. Defining general theory as it relates to the sciences is imperative for the framework of this study. Although there are many definitions of a theory, this study will use the above explanation as the lens for analyzing students' perspectives towards acceptance and understanding of evolution.

To reiterate, within this study I will use the term evolution as being extensively studied and proven within multiple phenomena, and evolutionary theories being tools to explain biological patterns. The expression "theory of evolution" will be limited in use within this study, unless current literature explicitly uses this terminology, in which case, I will examine how this language is framed and in what context the author is presenting their information.

Evolution in P-20 Curriculum Within the U.S.

The topic of evolution has been a controversial topic in public education and has had many challenges and changes within state science curriculum frameworks, textbooks, and discussions within the context of the classroom (Moore, 1999; Skoog & Bilica, 2002). Highlighting various methods of weakening the teaching of evolution, as well as fighting for the inclusion of evolution within public school curriculum serves as a backdrop for this study, in which I explore and analyze postsecondary students' perspectives toward accepting and understanding evolution. Three areas highlighted to build a framework around where evolution stands within current public education (K-12) and higher education are: biological evolution in state science standards, evolution in textbooks, and teachers' perceived abilities of discussing evolution in the classroom.

State science standards.

Public schools use science standards to frame topics of discussion, including controversial topics like evolution. The current organization of the American school system is one in which decisions are largely dictated at the federal level and implemented at the state level. The National Science Education Standards (NSES) were developed by the National Academy of Sciences in 1996. In 2000, evolution was included in standards-based teaching and mandatory testing (Glaze & Goldston, 2015). The newest national US standards are the Next Generation Science Standards (NGSS) created by the National Research Council in 2013 which "build upon the NSES foundation by using vertical scaffolding to connect concepts across grades in addition to scaffolding unifying concepts, including evolution, natural selection, and adaptation beginning in elementary

and continuing to secondary schools" (Pobiner, 2016). As of 2016, only 15 states and the District of Columbia had adopted the NGSS (Pobiner, 2016). Most state curricula standards "correspond generally to some degree, but are deeply different, especially when it comes to 'controversial' topics such as evolution" (Padian, 2010, p. 211).

The variation of state curricula standards is partly due to the individuals elected and serving on state education committees and boards. The decision to include, omit, or emphasize particular topics within the state curricula standards are influenced by the individuals serving on the state education boards, their constituents and local communities constitutes are the voice for (Watts, Levit, & Hoßfeld., 2016). The differences in local and state views could explain some of the variation in state science curricula, particularly concerning controversial topics.

As stated earlier, the scientific community holds a strong persistent agreement that the topic of evolution is a central theme throughout many biological fields, and is regarded as a vital part of science and science education (Nehm et al., 2009; Skoog, 2005; Quessada et al., 2008; Yates & Marek, 2014). Along with today's scientists, educators at various levels understand the importance of evolution for the teaching of science (Quessada et al., 2008). Currently, the National Science Teachers Association (NSTA) "strongly supports the position that evolution is a major unifying concept in science and should be emphasized in K-12 science education frameworks and curricula" (NSTA, 2010).

After examining science standards from 49 states and the District of Columbia, Skoog and Bilica (2002) outlined the inclusion of evolution in 92% of the middle and

secondary level science frameworks when broadly defining the overall concept of species change over time and the concept of natural selection. However, percentages changed when more specific aspects of evolution were examined within the science standards documents. For example, descent with modification was present in 42% of documents, pace of evolution was stated in 28% of documents, and human evolution in 10% of documents (Skoog & Bilica, 2002).

History of Evolution in Textbooks

In the 1920's, biology textbooks began to tie together many of the biological topics, where previously topics like botany and zoology were kept separate (Shapiro, 2008). "*Civic Biology* was the first of a new generation of textbooks that integrated the teaching of botany, zoology and human physiology into a single coherent whole, organized around common core principles of life" (Shapiro, 2008, p. 416). This book was used by the biology class taught by John Scopes in 1925, in which he assigned the students to read the evolution chapter (Moore, 2001).

Other books published and used at this time, such as Truman Jesse Moon's *Biology for Beginners*, incorporated the unifying principles of life, which included discussions of evolution plus human and ape's relationship to a common ancestor (Moon, 1921; Shapiro, 2008). Also, Benjamin Gruenberg's *Elementary Biology* discusses evolution extensively, with multiple chapters devoted to aspects of evolution, such as fossil evidence and classification of animal life from an evolutionary standpoint (Grabiner & Miller, 1974). Although there were textbooks which discussed evolution prior to the Scopes trial, many widely use textbooks omitted the topic of evolution,

reduced the topic to a brief mention, or left out discussion related to the origin of man (Grabiner & Miller, 1974).

Evolution in science textbooks after the Scopes Monkey Trial.

After John Scopes's conviction in 1925, textbook publishers removed mention of Darwin's theory of evolution and public schools decreased the amount of time devoted to the teaching of evolution (Grabiner & Miller, 1974; Moore, 2001). Hunter's *Civic Biology*, which Scopes used in his science class, went through a change after the trial, becoming the *New Civic Biology*, in which the paragraph about evolution was removed and the word evolution no longer appeared in the index (Grabiner & Miller, 1974). One of the most highly used biology textbooks after the Scopes trial was Smallwood, Reveley, and Bailey's *New General Biology*, which did not have reference to the word evolution (Grabiner & Miller, 1974). Ladouceur (2008) disagreed with the statement that evolution was being removed from textbooks and stated that "an evolutionary framework structured not only Moon's text, but also virtually every biology textbook published from about 1914 on" (p. 440) even if the word evolution was removed.

Along with the removal of the word evolution, many textbooks began to include religious quotations to make textbooks "worthy of adoption because the quotations showed that the books were 'tactfully written' and presented evolution as a 'theory and not as an established fact" (Moore, 2001, p.792). As Grabiner and Miller (1974) stated,

> The religious quotations which appear in some of these books, together with the near-disappearance of the theory of evolution and of Darwin's role in establishing

> it, demonstrates the impact of fundamentalist pressure in general, and the Scopes trial in particular, on the textbook industry (p. 835).

Evolution in science textbooks from 1930s to 1970s.

Moving into the late 1930's and 1940's, the discussion of evolution began to reemerge in some biology textbooks; however, many of the popular textbooks used continued to ignore the topic or insert evolution as an afterthought at the end of the textbook (Moore, 2001). With the rush to space and the Soviet Union's launch of Sputnik in the 1950's, revamping science and technology curriculum was ushered into focus.

In 1958, the National Science Foundation (NSF) grant funded the Biological Sciences Curriculum Study (BSCS), which in 1963 produced three versions of high school biology textbooks containing different emphases with different colors on the cover to distinguish between the three (Ladouceur, 2008; Moore, 2001). After discussion over the themes to be highlighted in the BSCS books, and revisions of the books in 1968, evolution was stressed and became a unifying theme of biology within the books (Ladouceur, 2008; Moore, 2001). Even though the three BSCS textbooks discussed evolution, coverage of the topic did vary depending on the version. Nicholas (1965) identified 17 evolutionary topics from the BSCS textbooks and noted that all 17 topics appeared in the BSCS Yellow Version, while the BSCS Green Version and BSCS Blue Version each had 15 of the topics. Within the three versions of the BSCS textbooks, evidences of evolution from paleontology and comparative anatomy, taxonomy and embryology were most frequently mentioned (Nicholas, 1965).

There was push back from the use of the BSCS books, one of the harder fights coming from two self-appointed textbook censors from Longview, Texas (Moore, 2001). "The BSCS books were denounced in newspapers, in church sermons, and at hearings of the Texas Textbook Commission," (Moore, 2001, p.793) eventually leading to the elimination of two of the BSCS books from the commission-approved list, after having been adopted in Texas. Also, states such as Texas insisted on changing statements about evolution, or requested statements to be deleted, such as, "To biologists there is no longer any reasonable doubt that evolution occurs" (Skoog, 1969, p. 45) within the BSCS Blue Version. Even with an increase in evolutionary content in textbooks in the 1960's, many states insisted on lessening or weakening the coverage of evolution within adopted textbooks (Swarts, 1991).

Evolution in science textbooks from 1970s to 2000s.

Heading into the 1970's and 1980's the overall coverage of evolution decreased according to research by Skoog (1979, 1984) and Rosenthal (1985). The data presented by Skoog (1969, 1979, 1984) has been foundational in quantitative research related to the changes in coverage of evolution in textbooks over time. Skoog organized evolutionary content into 44 different categories from 105 high school textbooks published between 1900 and 1983. Word counts were used to represent emphasis of each of the 44 evolutionary topics. Through the decades, increased emphasis was seen in evolution content from 1900-1950's, a de-emphasis on evolution in the 1950's, increase in the 1960's, and another decrease in the 1970's and 1980's. Skoog also witnessed a trend of placing chapters that were devoted to evolution later within the textbook. Rosenthal

(1985) stated that pages devoted to evolution decreased between 1963 and 1983; however, the textbook length also decreased.

After analyzing Skoog's (1969, 1979, 1984) data, Swarts (1991) discussed some of the shortcomings in this highly referenced foundational data. The weaknesses in Skoog's research that Swarts (1991) highlights included, (1) unclear examples of text used in the characterization of the 44 evolutionary categories delineated within the study; (2) the methods for categorizing the text were not described and tests of validity and reliability were not reported; (3) the overall amount of text, including non-evolutionary content, was not analyzed; (4) trends were discussed between specific time periods even though each time period had differing numbers of texts used.

Examinations of evolutionary content in high school textbooks were also conducted by Hughes (1982) and Rosenthal (1985), both using qualitative methods within their research. After examining 20 biology textbooks, Rosenthal (1985) stated that there was a "substantial decrease in attention to evolution" (p. 646). Rosenthal (1985) examined the percentage of space devoted to evolution in 22 high school biology textbooks published between 1963 and 1983. Biology textbooks published prior to 1979 contained a mean of 13 percent coverage of evolutionary topics, while after 1979 that percentage dropped to 9.9 percent coverage. The number of pages dedicated to evolution decreased from 52.4 to 32.5 during this timeframe, concurrently with the decrease in overall textbook length. Rosenthal (1985) stated that the quality of evolutionary coverage declined during the years 1963-1983, such as confusion between fact and theory when connected to evolution.

In 1987, Woodward and Elliott examined 15 high school biology textbooks published around the early 1980's for their coverage of evolutionary content. Woodward and Elliott (1987) grouped the textbooks into four general categories based on the treatment of evolution. Two of the 15 books were labeled as "avoiding evolution and Darwin", three books were described as a "balanced" approach, in which "efforts were made to emphasize the uncertainty of scientific prediction and the difficulty of observing and thus 'proving' evolution" (p. 168). The books in the "balanced" approach category also provided alternative theories to evolution. Four of the 15 books examined were classified as "textbooks excluding human evolution" and six books were "textbooks with full coverage of evolution" (Woodward & Elliott, 1987).

Evolution in science textbooks in the 2000s.

In the early 2000's the topic of evolution in public school curriculum, particularly in textbooks, fell under attack in Texas. Texas is one of two states, California being the other, that spend the most on textbooks, and publishers cater to these states' curriculum standards (Sewall, 2005). During the textbook adoption process in 2003, anti-evolution members of the Texas Education Agency's (TEA) science textbook adoption review panel and members of the public, standing against evolution in textbooks, stressed that the textbooks under review did not satisfy the Texas Essential Knowledge and Skills (TEKS) standards. The adoption review panel sought to discredit evolution and include other theories of the origin of life, such as creationism, into the textbooks being adopted for the Texas public school system (Evans, 2003). Hearings and written statements were conducted with both scientists and educators expressing the concern for the attempts to

undermine the treatment of evolution in textbooks by anti-evolution supporters. After the arguments were reviewed for textbook adoption in Texas, an 11-4 vote approved all 11 textbooks submitted for adoption (Evans, 2003). These 11 textbooks discussed evolution without the inclusion of creationism and would be used in other states besides Texas.

State science standards, adopted textbooks and new bills are changing every year concerning the topic of evolution. In 2017, eleven measures that attacked science education were introduced into legislative sessions in eight states (Carr, 2017). State Senators like Oklahoma Senator Josh Brecheen insisted on offering legislation every year with the intention of requiring Oklahoma schools to teach the debate of creation vs. evolution (Carr, 2017). Changes in legislation, science standards, and course material will impact the way teachers discuss the topic of evolution in the classroom as evidenced in this historical review of the treatment of evolution in U.S. science curriculum and textbooks.

Factors Influencing Evolution in Textbooks

The inclusion or omission of evolution in textbooks is one of many sides to the story of evolution in public schools; a story that also includes state standards, legal and policy issues, and the thoughts and beliefs of local communities, educational leaders, teachers, and students (Grabiner & Miller, 1974; Ladouceur, 2008; Lerner et al., 2012). As described earlier, the relationship between teacher and instructional materials, relating to evolution, stems back to the Scopes trial in 1925. The genesis of the Scopes trial developed from John T. Scopes assigning students to read chapters on evolution from the class textbook, Hunter's 1914 *Civic Biology* (Hermann, 2013). Evolution was not a new

topic at this time and had been accepted by scientists for many years; however, changes affecting biology education were culminating around the 1920's, opening the door for the conversation of evolution in public schools (Shapiro, 2008).

The inclusion of evolution within science textbooks has increased since the time of the Scopes trial in 1925. However, anti-evolution pressures continue to influence evolution content (Lerner et al., 2012). With the change to compulsory education in the 1920's, textbook industries increased production of textbooks and could focus on fewer version with the development of nationwide school subjects (Shapiro, 2008). Although textbooks companies stated their neutrality in the conversation around compulsory education, the business of textbook production clearly benefited from this educational change (Shapiro, 2008).

The decisions on adopted textbooks can be dissimilar depending on the decisions of state boards of education, and the content surrounding evolution can vary depending on the state (Shapiro, 2008). Also, textbook providers will modify the product to best match the current editions of the state standards, particularly for states that have high adoption numbers within school districts (Watt, 2007). With the number of factors that influence textbook content, coverage of controversial topics like evolution can change through time and locality.

With the introduction of compulsory education, states became responsible for uniform textbook adoption, making choices based on textbook content. Historically, the majority of states that choose to adopt textbooks are located in the southern regions of the United States, which embodies inherent social values and political views (Grabiner &

Miller, 1974; Tulley, 1985). As with any location, the history and socio-cultural aspects of an area influence discussions made by state education boards when adopting textbooks.

Acceptance of evolution.

The discussion of evolution in science classrooms can influence students understanding and acceptance of evolution when out of school (Nehm & Schonfeld, 2007). Miller et al. (2006) was published in *Science* and recorded the true or false responses from individuals in 33 countries to the following item: "Human beings, as we know them, developed from earlier species of animals" (p. 765). According to this study, evolution acceptance rates in the United States at that time lingered around 50%. The percentage of adults in the United States accepting or rejecting evolution shifted to the individual feeling uncertain on their stance surrounding the topic (Miller et al., 2006). Although results of this study have been widely cited, there exist reliability and validity concerns due to the use of a single-item measure that is not necessarily directly related to acceptance (Smith & Siegel, 2016). Similarly, in a Harris poll conducted in 2013, which individuals were asked if they believed in evolution and other ideas, 47% of respondents stated that they believed in evolution, 29% did not believe in evolution, and 25% were not sure (Pobiner, 2016). This poll also focused on acceptance and belief in evolution and not specifically on an understanding of evolution. Individuals who accepted evolution were more likely to have advanced college degrees (Berkman & Plutzer, 2011).

Various factors can influence acceptance of evolution, such as conflict between religious beliefs, education, and political impacts (Heddy & Nadelson, 2013). Barnes &

Brownell (2018) stated, “a person’s religious beliefs and religious culture are the greatest indicators of rejecting biological evolution” (p. 37). A better understanding of factors that affect an individual’s understanding of evolution can be positive for scientific development and the support for science endeavors by society (Miller et al., 2006). Agricultural business, medical advances, examination of substances that can harm humans and other animals, conservation, and understanding diseases are several areas in which an understanding of evolution is critical (Heddy & Nadelson, 2013; Rice et al., 2015). The reluctance to accept evolution by the public is antagonistic to the advocacy of scientific organizations for inclusion of evolution in public schools. “Science teachers are an important “missing link” between scientists’ understanding of evolution and the general public’s ignorance of or resistance to the idea” (Nehm & Schonfeld, 2007, p. 701).

Anti-evolution pressures.

Although many state curricular standards include the topic of evolution, anti-evolution pressures have been present for many years attempting to omit, lessen, or create doubt in evolution and threaten state science standards (Lerner et al., 2012). “With regard to evolution specifically, three main “pillars” of contemporary anti-evolution efforts include casting doubt on some aspect of evolution or discrediting it as controversial, demanding “equal time” for nonscientific alternatives in the name of “fairness,” and emphasizing the incompatibility of science and religion” (Pobiner, 2016, p. 235). Dr. Barbara Forrest, an expert witness in the Kizmiller v. Dover trial, also stated the use of language to hide creationist agendas and promotion of “academic freedom”

bills in many states (Forrest, 2018). The push to remove evolution from science curricula has created a history in U.S. courts of the tug-of-war between evolution and creationism in public schools (Speake, 2011).

Court cases involving evolution in science curricula.

Several cases involving evolution in the classroom will be highlighted to illustrate the fight to teach evolution in science classrooms. One of the most well-known anti-evolution court cases is the "Monkey Trial" of 1925, in which John Scopes, a science teacher in Tennessee, went to trial for teaching the theory of evolution in his high school class (Larson, 1997). When Scopes was found guilty, the *Butler Act* was written and stated that it was "unlawful to teach any theory that denies the story of divine creation as taught by the Bible and to teach instead that man was descended from a lower order of animals" (Tennessee Anti-Evolution Statutes of 1925).

Although there have been many court cases involving the Establishment Clause of the First Amendment after the Scopes trial in 1925, only those cases that surround the teaching of evolution will be highlighted. The Establishment Clause has been used to separate church and state, and in the case of public schools, remove religious activities from public education (Jeffries & Ryan, 2001).

In 1968, anti-evolution law was challenged for the first time since the Scopes trial in 1925 with the *Epperson v. Arkansas* cases (Moore, 1999). The ruling in this cases "legalized the teaching of evolution in Arkansas, ruled that laws banning the teaching of evolution were unconstitutional, and made it unconstitutional to ban the instruction of one theory and not another" (Moore, 1999, p. 10). In 1981, *Segraves* v. *State of*

California challenged the wording within *The Scientific Framework for California Schools* causing the California Board of Education to "circulate a statement stressing the need to eliminate dogmatism and include qualifying statements about speculations on the origins of life" (Moore, 1999, p. 14).

The methods for decreasing or eliminating evolution in the classroom have evolved over the years, from a clear ban on the teaching of evolution, to questioning the terminology defining evolution, creating doubt about the theories surrounding evolution and the call to including other views pertaining to the existence of humans alongside the teaching of evolution. The cases *McClean v. Arkansas* (1981) and *Edwards v. Aguillard* (1987) both resulted in removing the requirement of teaching both evolution and creation science equally in the classroom (Speake, 2011). Specifically, the U.S. Supreme Court, struck down the Balanced Treatment Act in *Edward v. Aguillard* that required Louisiana public schools to "teach creationism if they taught evolution and vice versa" (p. 456), and held this to be a violation of the Establishment Clause of the First Amendment (Beckwith, 2003). After this decision, Intelligent Design (ID) proponents avoided references to God, and instead pushed for empirical inquiry instead (Pobiner, 2016). During *McClean* v. *Arkansas* (1981), Judge Overton concluded that the Arkansas statute, Act 590 of 1981, which mandated public schools to give balanced treatment to creation-science and evolution, violated the Establishment Clause when analyzed with the three-prong *Lemon* test (Beckwith, 2003).

In later years, court rulings have upheld the right of school districts to require teachers to teach evolution (Moore, 1999). In 1990, during *Webster v. New Lennox*

School District, a school teacher claimed that being prevented from teaching creationism in the classroom by the school district violated his First Amendment rights. The court found that the teacher's First Amendment rights were not violated, and that "the school district can prohibit a teacher from teaching creation because it endorses religion" (Speake, 2011, p. 47). In *John E. Peloza v. Capistrano Unified School District* (1994), the courts also declared that teaching evolution does not violate the Establishment Clause of the U.S. Constitution because evolution is not a religion (Moore, 1999).

More recently, cases involving the discrediting of evolution and providing alternatives to the origin of life have been presented. *During LaVake v. Independent School District* in 2000, a teacher "argued his right to teach evidence 'for and against the theory' of evolution (Speake, 2011, p. 47). This case was dismissed when the judge declared that the teacher's free speech rights did not override the required curriculum (Speake, 2011). In 2005, during the *Ketzmiller v. Dover* case, parents from the Dover area filed suit against the Dover Area School District School Board for incorporating an intelligent design policy that allowed teachers to present intelligent design as an alternative explanation for the origin of life that differed from Darwin's theory of evolution (Superfine, 2009). It was found that this policy was a violation of the Establishment Clause of the U.S. Constitution (Speake, 2011; Superfine, 2009).

The fight to include creation-science in public schools continues to be pushed in state legislatures. Lerner et al. (2012) mentioned Louisiana's Science Education Act passed in 2008, which gives "teachers and students legal cover to debate the merits and veracity of scientific theories" and "allows for the introduction of creationist teaching

supplements" (p. 9). In 2011, eight other anti-evolution bills were introduced in six state legislatures, but were denied passage into law (Lerner et al., 2012). Proponents of Intelligent Design continue to fight for inclusion of creationist views in public schools by introducing "academic freedom" bills into state policies, with many of them continuing to be denied (Forrest, 2018).

Thus, inclusion of the topic of evolution in secondary public schools can be accomplished or denied by the teacher of the class, the state standards, or school board policies. Other educational materials that have been under scrutiny for the inclusion of evolution are textbooks and other instructional materials used by students.

Factors Influencing Teachers' Willingness to Teach Evolution

The history of evolution in science curricula has resulted in research examining the ability and willingness to teach the subject. Some studies have shown that the controversy around the topic of evolution can lead to emotional stress for teachers and negative perceptions surrounding evolution (Brem et al., 2003; Griffith & Brem, 2004). Some of the factors that led to emotional stress were the unwillingness to teach evolution, the feeling of not being adequately prepared to teach evolution and/or holding misconceptions about evolution content, misunderstanding about the nature of science, personal beliefs, and challenges from communities, school boards, and parents when teachers follow states standards and teach evolution (Aguillard, 1999; Borgerding et al., 2015; Nehm et al., 2009; Shankar, 1989).

In a study conducted by Brem et al. (2003), secondary teachers avoided controversy when teaching evolution, and "most of the teachers we worked with either

actively avoid these issues or worry deeply about conflicts amount parents, teachers, and administrators" (p. 184). Although evolution is included in many state curriculum standards, teachers may avoid the topic or designate minimal time to evolution while keeping the discussion at a superficial level (Brem et al., 2003). Also, school districts have used tactics to question the validity of evolutionary theory leading to opportunities for students to learn alternate theories, such as intelligent design (Berkman & Plutzer, 2011). Berkman and Plutzer (2011) expressed that "in the absence of high stakes assessment tests, local public opinion is an important influence on how the policy (of omitting creationism from the curriculum) is actually implemented and completely trumps the curricular standards developed and adopted at the state level" (p. 630).

Teacher's personal values can also enhance the local sentiment or be counter to the views of the community and school board in relation to controversial topics. Teachers may teach near the communities where they grew up after obtaining their education, areas in which their views align with the parents and school administration (Boyd et al., 2005). Boyd et al. (2005) concluded "prospective teachers appear to search very close to their hometowns and in regions that are similar to those where they grew up" (p. 127). Meadows et al. (2000) categorized teachers conflicting ideas between evolution and religion onto four groups, (1) teachers who are unaware of conflict and compartmentalize their beliefs about religion and beliefs about evolution, (2) teachers that are aware of conflict between their beliefs about religion and evolution, (3) teachers that are disturbed by the conflict between beliefs about religion and beliefs about evolution and begin to actively seek some sort of resolution, and (4) teachers who

manage the conflict and move back and forth between the two systems of beliefs comfortably.

Another concern related to the ability of teachers to correctly provide students information about evolutionary topics is misconceptions held about evolution by both pre-service and in-service teachers. Some of the documented misconceptions about evolution and the nature of science are confusion between "theories" and "facts", evolution cannot be "proven", and evolution is a weak scientific idea because it is a "theory" (Nehm & Schonfeld, 2007). Seventy-five percent of teachers (n=44) who took a course addressing misconceptions about evolution showed a positive and significant increase in their knowledge of the topic (Nehm & Schonfeld, 2007). However, researchers found that 50% (n=21) of teachers preferred that students be taught some amount of creationism in schools even after completing a course designed to address documented misconceptions of evolution (Nehm & Schonfeld, 2007). Would it be appropriate to conclude that an evolution education course for teachers was successful if teachers achieved statistically significant gains in their knowledge of evolution, but continued to allow discussions of creationism in the classroom? It should be made clear that it is not illegal to discuss creationism in science classrooms, but the law dictates how religion is spoken about and the purpose of such discussion (Pobiner, 2016). Pobiner (2016) summarizes Hermann's (2013) legal parameters for teaching evolution and creationism and states,

> It is not illegal to discuss creationism in science classrooms as long as teachers provide a neutral approach to discuss the creation stories of various religions,

> being clear that this discussion is aimed at differentiating between science and non-science, and acknowledge that a controversy about teaching evolution exists while then devoting instructional time to evolution without 'teaching the controversy'. (p. 248)

After examining 167 precertified science teachers in New York City, whom were also employed full-time due to teacher shortages, Nehm et al. (2009) concluded that there were no significant differences between biology and non-biology teachers' perspectives on teaching evolution in schools. "Biology and non-biology teachers displayed comparable perspectives on creationism; nearly half of the teachers in both groups preferred that creationism be included with evolution in the classroom" (Nehm et al., 2009, p. 1138). Berkman and Plutzer (2011) indicated that 13% of 926 teachers surveyed advocated for teaching creationism, while 60% of the same teachers surveyed avoided discussion of evolution or alternatives to avoid controversy. An instructors' decision to discuss creationism alongside evolution in a secondary school science class could have effects on the students' knowledge of evolution within college courses. Moore et al. (2011) found that "inclusion of creationism in high school biology courses is strongly associated with students' knowing less about evolution when they get to college" (p. 225). A student's religious beliefs are also associated with decreased knowledge of evolution, regardless of the secondary school instruction of evolution (Moore et al., 2011).

Instructors perception of their ability to understand and teach evolution can vary from very confident in understanding the topic of evolution (99.2% of Ohio teachers

reported understanding evolution well enough to teach the topic) to decreased confidence in the ability to teach the subject (two thirds of Minnesota biology teachers felt they did not have proper undergraduate training to teach evolution) (Aguillard, 1999; Borgerding et al., 2015; Friedrichsen et al., 2016; Moore & Kraemer, 2005). Aguillard (1999) confirmed "significant correlation between instructional time devoted to evolutionary theory and respondents' credit hours in biology, respondents' number of college courses specifically exposed to evolution, and school enrollment" (p. 184).

Although state science standards include the instruction of evolution, the teacher ultimately introduces the topic to the students. Friedrichsen et al. (2016), after reviewing several articles, summarized that high school science teachers spend on average 15 hours discussing evolution and foundational theory of biology. Of the time spent teaching evolution, many teachers address the topic as a stand-alone unit and not as a unifying theme (Friedrichsen et al., 2016). To avoid the controversy around teaching evolution some teachers will avoid using the word evolution, eliminate instruction of human evolution, spend little time on macroevolution/speciation, or encourage students to understand evolution without accepting the topic (Borgerding et al., 2015; Friedrichsen et al., 2016; Griffith & Brem, 2004; Pobiner, 2016)

Secondary school and pre-service teachers may feel inadequate in teaching the topic of evolution or anticipate/avoid the potential controversy from students, parents or administration as a reason for avoiding or minimizing the discussion of evolution (Köse, 2010; Rutledge & Mitchell, 2002). Also, teacher's personal religious beliefs or views could influence how a topic such as evolution is presented in the classroom (Köse, 2010;

Rutledge & Mitchell, 2002). Due to the position and instructional approaches teachers use when discussing evolution, their participation in how and to what extent evolution is included in the content of the classroom is important to be mindful of.

When a student enters post-secondary school, they may come with pre-conceived ideas about evolution; however, that does not omit the effects a faculty member at a college or university could have on a students' understanding of the topic. Rice et al. (2015) examined the relationship between 309 university faculty members' knowledge and acceptance of evolution across several factors, such as theistic position, academic discipline, and amount of science courses taken at the post-secondary level. Results of this study showed that for university faculty, higher knowledge of biological evolution positively correlates with higher acceptance of biological evolution, regardless of theistic views (Rice et al., 2015). Rice et al. (2015) also found a positive correlation between higher knowledge of biological evolution and higher acceptance of biological evolution in all areas of expertise except Veterinary Medicine, which showed no correlation in either direction. Also, those "participants who stated that they had taken nine or more science courses in college scored significantly higher on both the measures of knowledge of biological evolution and acceptance of biological evolution, when compared to those participants who had received less" (Rice et al., 2015, p. 11).

Relationship Between a Students' Personal Beliefs and Accepting Evolution.

Students may come into a classroom with little scientific understanding of evolutionary process, while holding beliefs about the theory (Cavallo & McCall, 2008; Chinsamy & Plaganyi, 2007). A student's religious or social beliefs may lead to aversion

or a disregard of evolution all together (Barnes et al., 2017b; Cavallo & McCall, 2008; Sinclair et al., 1997). Students may also carry misconceptions or have a weak understanding of the nature of science and what constitutes "scientific theory" in general (Cavallo & McCall, 2008).

Sinatra et al. (2003) explains that "lack of acceptance can serve as a barrier to developing a scientific understanding of the construct" (p. 512). Several studies have concluded that a negative relationship exists between an individual's religious beliefs and accepting evolution; however, researchers have also found that there is little or no relationship between an individual's religious beliefs and understanding evolution (Bishop & Anderson, 1990; Demastes et al., 1995). "A person may understand a topic (evolution, for example) without significant incorporation into his/her belief" (Blackwell et al., 2003, p. 61).

Students that take science classes that include discussion of evolution may not change their acceptance of evolution after completing those courses. Bishop and Anderson (1990) found that 67% (n = 32) of students that stated their beliefs about evolution, pre and post instruction of the topic, did not change their answers and that the 11 students that did change their beliefs about evolution did so between the category of unsure to the believer or nonbeliever categories. No student surveyed changed their belief about evolution from believer to nonbeliever or vice versa after instruction on the topic of natural selection and evolution. Also, "students who improved their understanding of the process of natural selection did not generally change their convictions about the truthfulness of the theory" (Bishop & Anderson, 1990., p. 426).

When McKeachie et al. (2002) examined 75 students enrolled in an introductory biology course at a community college and their relationship between personal religious beliefs and evolution, many students who held creationist beliefs either dropped the course or avoided filling out the post questionnaire. Of the three creationist students that remained in the course and participated in the post questionnaire, their grade in the course was significantly lower than students that accepted evolution in some form.

Ingram and Nelson (2006) used McKeachie et al.'s (2002) study as a foundation for examining students' attitudes toward evolution and the influence of their attitudes on their performance in an upper-level evolution course. The population of students examined was larger than that of McKeachie et al. and the students in this study were upper-level students that had many of the biology requirements for the major completed. When students' achievement in the course was compared to their acceptance of evolution, the researchers "found that students' acceptance of evolution was not strongly related to their achievement in the course" (Ingram & Nelson, 2006, p. 16). Students' acceptance of evolution did increase after tallying the post-questionnaires. This finding differs from Bishop and Anderson's (1990) finding about students' change in attitude toward evolution after instruction. One possibility for the difference in students change in acceptance of evolution after instruction on the topic could be the length of time students were exposed to evolution. During Ingram and Nelson's (2006) study, students were enrolled in an entire semester-long course on evolution.

Many students enter college level courses with misconceptions or lack of understanding of the mechanisms of evolution (Sinclair et al., 1997). Some of these

misconceptions include believing that individual species could adapt to a changing condition with enough individual effort, inability to comprehend the mechanisms of speciation and natural selection, and misunderstanding the ancestral relationships between humans and other primates (Sinclair et al., 1997).

Hermann (2012) found that high school students surveyed had a lack of understanding of the nature of science (NOS) and a "poor understanding of the methods and underlying philosophy of science" (p. 625). For example, students could not accept evolution under the conclusion that it is "just a theory" and is not true until it is actually proven (Hermann, 2012). Hermann (2012) explains,

> The lack of understanding of NOS allows for the compartmentalization of knowledge by categories of belief. In the absence of a requirement of verifiable and replicable experimental evidence, a requirement of truth and proof are substituted, since truth and proof cannot be obtained as "just a theory" and disregarded as a way of knowing. In place of the theory, a religious understanding is maintained despite the fact that it, too, lacks the aforementioned criteria of truth and proof. Again, the ambiguous nature of compartmentalization surfaces within context of NOS to justify the exclusion of scientific belief from one's belief system" (p. 625).

When students taking an introductory college zoology course were surveyed pre and post instruction, one-third of the 218 students could not correctly define a scientific theory (Sinclair et al, 1997). "In the line of reasoning, as students develop a more sophisticated understanding of the nature of science (NOS) – understanding the

fundamental assumptions of science and its methodologies, limitations, and boundaries – they are also more prone to accept evolutionary theory" (Sinatra et al., 2003, p. 514).

The information that students receive from life experiences, and their time in various forms of the education system, mold the decisions they will make as adults in the larger scope of society. "Students who understand but do not accept evolution are unlikely to apply evolutionary thinking when making public decisions related to biology" (Barnes & Brownell, 2018, p. 38). Examining the current research related to a students' understanding of evolution may give insight in their ability to make decisions on how humans coexist with each other and the larger environment we exist in and manage. "Voters who do not incorporate deep time and the coevolution of species into their thinking may not be able to fully appreciate the complex interconnectedness of all organisms on Earth and thus the extent to which the extinction of one species, or the pollution of one environment, might affect global biodiversity" (Barnes & Brownell, 2018, p. 38).

The relationship between understanding evolution and accepting evolution by a student is not always a simple linear connection (Barnes et al., 2017b). The amount of information and exposure to evolution prior to a student pursuing a postsecondary degree in a science field can vary depending on the students' secondary education, family and cultural influences, and religious beliefs. If a student decided to pursue a degree in a science related field, the information and views about evolution they are coming in with could influence their success and persistence in that field. The National Science Standards views evolution as a unifying theory in biology education (National Research

Council, 1996). Evolution is also a foundational component of introductory and upper-level college biology courses (Barnes et al., 2017a). It is beneficial to examine what factors influence a student's understanding and acceptance of evolution through their career in a post-secondary institution.

Students' Understanding and Acceptance of Evolution in Current Literature

Worldview Lens.

Every person filters scientific understanding through personal beliefs, identity and culture, particularly topics that are viewed as controversial (Glaze, 2017). It is dangerous for researchers to "assume that students come into elementary, secondary, and college science classes with relatively homogeneous, fundamental views of the natural world capable of assimilating and valuing modern scientific understanding when science knowledge is presented in proper enquiry fashion" (Cobern, 1991, p. 3). Worldview is a theoretical point of view in which "each person can be seen as having a fundamental, epistemological macrostructure which forms the basis for his or her view of reality" (Cobern, 1991, p. 7). A student's world view is a lens through which we view interpret, and judge all experiences throughout our lifetime and can be influenced by formal science instruction (Glaze, 2017; Cobern, 1991).

Difference in worldview sheds light on the variation in accepting evolution between scientist and the general public. "We all act according to our own perceptions of importance and reality but in the scientific community perceptions are more narrowly focused on science" (Cobern, 2000, p. 240). The potential for competing interest by the

public can result in the science community and the general public understanding science in different ways (Cobern, 2000).

Drawing upon how our worldview influences decision making and interactions with the world, this study was guided by the worldview to analyze each of the studies. This theoretical grounding provided a context to determine students' perspectives towards acceptance and understanding of evolution as well as the presentation of this information by the researcher.

Summary

This chapter has focused on the history of evolution in science textbooks, review of court cases related to teaching evolution, the controversy and willingness of teachers to teach evolution, and current literature surrounding student understanding and acceptance of evolution. This qualitative metasynthesis study will explore and analyze postsecondary students' perspectives towards accepting and understanding evolution. Chapter III focused on the methodology of meta-synthesis and use of this methodology in this current study.

CHAPTER III

Methodology

Introduction

The previous chapters defined the problem, questions and review of literature pertaining to this qualitative meta-synthesis study. This chapter outlines the methodology used to conduct this research. This chapter includes: an overview, research design, the role of the researcher, data collection, data analysis, provision of trustworthiness and summary.

Overview

The purpose of this qualitative meta-synthesis is the exploration and analysis of postsecondary students' perspectives towards acceptance and understanding of evolution. This chapter explains the methodology known as qualitative meta-synthesis. Qualitative meta-synthesis is a research method that seeks to extract concepts, compare, and contrast results of primary qualitative studies and synthesize these results into taxonomies detailing the range of conceptual findings across studies (Saini & Shlonsky, 2012). Educators and policy makers may utilize this study to support their students' continued interest in the biological sciences throughout their academic careers.

Research Design

Aguirre and Bolton (2014) explained "Synthesizing qualitative research allows for knowledge gleaned from individual qualitative studies of a particular phenomenon to come together in a broader, in-depth, and more holistic understanding of that phenomenon" (p. 280). Approaches for qualitative syntheses vary along a continuum based on a list of criteria for the study. When making a decision on a qualitative method the decision can be "based on the following criteria: (a) the epistemological and ontological stance of the researcher; (b) whether the research question is predefined or iterative; and (c) whether the method is aggregative, integrative, or interpretive" (Saini & Shlonsky, 2012, p. 24). The extremes of qualitative synthesis can be visualized in the following diagram by Finlayson and Dixon (2008).

Figure 1. Visual Representation of the Qualitative Synthesis Continuum

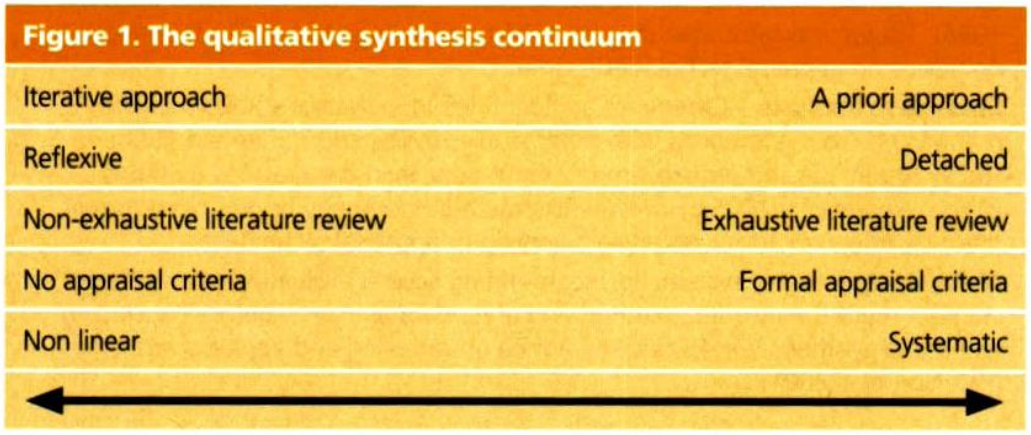

Figure 1. Schematic of the continuum of qualitative synthesis methods. The criteria listed should be considered when choosing a method that best suits the papers to be synthesized. From "Qualitative Meta-Synthesis: a Guide for the Novice," by K. Finlayson and A. Dixon, 2008, *Nurse Researcher, 15*, p. 61. Copyright 2008 by ProQuest Nursing & Allied Health Source.

Variations of Qualitative Synthesis

An interpretivist framework was used during the construction of this study. With the use of this epistemological/ontological approach, the researcher "supports the interpretive understanding of social actions of individuals and the subjective/intersubjective meanings generated by these social actions (Saini & Shlonsky, 2012, p. 13). Qualitative research assumes that reality is socially constructed and the use of qualitative inquiry is rooted in the *emic* viewpoint, which captures the respondent's point of view, rather than the outsider's point of view, *etic* (Saini & Shlonsky, 2012). The interpretivist framework "make(s) no distinction between objective and subjective knowledge given that all meaning is understood to be open to reinvestigation or reinterpretation" (Saini & Shlonsky, 2012, p. 13).

A qualitative synthesis study can be guided by predefined research questions or an iterative approach. Bondas and Hall (2007) suggested using research questions to assist in comparing the studies that will be included in the meta-synthesis. Saini & Shlonsky (2012) stated,

> Predetermined questions are often defined early in the review process; these are based on prior research, theory, or practice wisdom; and these questions provide the structure for creating themes categories across studies so that summaries of the findings of each study can be pooled or integrated across studies. (p. 26)

By using iterative questioning techniques, the question could be modified as a response to the results and findings of the reviewed items and avoids setting meaning to, or specifying concepts, in advance (Dixon-Woods et al., 2006; Saini & Shlonsky, 2012).

In this exploratory qualitative meta-synthesis, an iterative approach to the research question was used. The overarching question examined postsecondary students' perspectives towards acceptance and understanding of evolution and this question guided the search results for the qualitative studies that were examined in this study. With the use of an iterative questioning approach, the findings from the retrieved items may cause the question to be revised. According to Eakin and Mykholovskiy (2003), "the research question functions more as a compass than as an anchor, and is sometimes not really known until the end of the research" (p. 190).

The use of predetermined questions versus an iterative approach for a qualitative synthesis guides the approach used to synthesize the studies being used (Saini & Shlonsky, 2012). The approach of a qualitative synthesis can be categorized into three methods: aggregative, integrative, and interpretive.

The aggregative method uses qualitative studies from a specified research field and "employs a quantitatively oriented aggregation approach design" (Saini & Shlonsky, 2012, p. 27). An example of using an aggregative approach would be to determine effect size through frequency and intensity of terms within the collection of quantitative studies selected (Aguirre & Bolton, 2014). For this method of study, a clear predefined question is needed to guide the analysis and synthesis (Saini & Shlonsky, 2012). Qualitative syntheses that use an aggregative approach include meta-summary, content analysis and case survey.

Although the integrative method also focuses on summarizing findings from selected studies, the results "create taxonomies of the range of conceptual findings and

provide the foundation for the development of conceptual descriptions of phenomena across studies" (Saini & Shlonsky, 2012, p. 29). An integrative approach could be used to search for interconnected themes across studies, that viewed collectively, add insight to a particular problem. The parameters of an integrative approach for extracting data on a topic are defined early in the synthesis process in order to construct categories or themes that frame the studies being synthesized (Dixon-Woods et al., 2005). "The objective of integrative methods is to synthesize qualitative findings across studies in order to produce new integrated, descriptive, and explanatory interpretations and perspectives of an event, phenomenon, or experience" (Saini & Shlonsky, 2012, p. 30).

In contrast to an integrative approach, an interpretive approach to synthesizing qualitative data "will avoid specifying concepts in advance of the synthesis" (Dixon-Woods et al., 2005, p. 46). The interpretive approach "use an iterative process to explore what might be involved in similar situations and to understand how things connect and interact" (Saini & Shlonsky, 2012, p. 31). It is important to note some overlap between the three methods of qualitative syntheses in practice (Dixon-Woods et al., 2005).

Meta-Synthesis

"Qualitative meta-synthesis is an interpretive integration of qualitative findings that are themselves interpretive syntheses of data, including phenomenologies, ethnographies, grounded theories, and other integrated and coherent descriptions or explanations of phenomena, events, or cases" (Thorne et al., 2004, p. 1358). As stated above, the use of a broad research question will guide the review of qualitative studies related to post-secondary students' perspectives towards acceptance and understanding of

evolution. The use of a meta-synthesis methodology requires "a priori strategies for data collection, inclusion and exclusion criteria, data analysis, dealing with possible sources of bias, and synthesis of findings" (Saini & Shlonsky, 2012, p. 30).

Meta-synthesis is not a search for the answer to a problem, nor is it an account of the problem or question being explored (Finfgeld, 2003; Thorne et al., 2004). When applied to a particular problem or body of research, meta-synthesis "reduces, but does not eliminate, uncertainty" (Thorne et al., 2004, p. 1346). Thorne et al. (2004) described the systematic approach of meta-synthesis in the following steps,

> A specific problem is defined; inclusion criteria are explicated; a retrieval process is identified; characteristics of the study are measured on a common scale; findings are identified, classified, and coded; findings are aggregated; and indices of effect magnitude are calculated and, ultimately, transformed into a new conceptualization. (p. 1346)

A meta-synthesis results in findings that are more extensive than the results of the initial individual investigations, and provides "clarification of concepts and patterns, and results in refinement of existing states of knowledge" (Finfgeld, 2003, p. 894).

Role of the Researcher

In qualitative studies the researcher is considered an instrument of data collection. In this study, the researcher's role was interpretive in nature. Due to the role of the researcher during the selection and analysis of original studies, personal values can influence the direction of the study. "Even before data is analyzed, interpreted and presented the researcher's method of sampling, experimental design or questionnaires are

likely to reflect their (often unconscious) values" (Greenbank, 2003, p. 792). During the scope of this study, the researcher's biases and values were clarified for transparency throughout the process.

At the time of the study, the researcher was serving as a post-secondary educator in the science department of a comprehensive, state-supported, masters-granting regional university in Texas. During the researcher's instructional job duties, the topic of evolution is routinely discussed and supported with classroom instruction and research. The inclusion and exclusion criteria were designated by the researcher; however, the researcher was not involved in creating any new data, as all the studies used were archival.

Data Collection

The first step in conducting a qualitative synthesis is to formulate a question that provides "focus, direction, and an articulation of details about potential resources needed to carry out the review" (Saini & Shlonsky, 2012, p. 75). The question should also be "broad enough that a sufficient number of studies can be gathered during the search process" (Major & Savin-Baden, 2010, p. 109). The purpose of this qualitative meta-synthesis is the exploration and analysis of postsecondary students' perspectives towards accepting and understanding evolution. The following questions guided this qualitative meta-synthesis:

1. What perceived conflicts do post-secondary students face when learning about evolution?

2. Based on post-secondary students' perspectives, how do personal religious beliefs influence understanding and accepting evolution?

With these research questions in mind, the researcher needs to be self-aware during the process of identifying studies to include in the qualitative meta-synthesis. Major and Savin-Baden (2010) listed the following steps to consider when selecting studies, "setting the parameters for source materials, determining the search strings, setting the inclusion and exclusion criteria, and appraising the studies (p. 48). Depending on the topic being studied, there is argument for both a comprehensive sample of studies or collecting a sample of studies that reaches a point of theoretical saturation (Saini & Shlonsky, 2012).

For this qualitative meta-synthesis, the researcher initially identified as many scholarly published articles as possible; however, when "it becomes clear that fewer and fewer themes are recurring then a form of temporary saturation will have been reached and thus it is not important to continue analyzing articles" (Major & Savin-Baden, 2010, p. 53).

The selection of studies included in this meta-synthesis followed differing levels of screening. The number of checkpoints for a qualitative synthesis can vary depending on the topic being reviewed; however, having a "predeveloped set of inclusion criteria ensures transparency and helps guarantee the credibility of the screening process" (Saini & Shlonsky, 2012, p. 102). During the initial screening process, a broad set of questions

was used to determine if the study under review should move to the next round of screening.

The following inclusion criteria were used for the initial sample of studies: (a) the findings from the sample studies have been either published in a peer-reviewed journal or within a doctoral dissertation; (b) the participants had to have been college students enrolled in a post-secondary institution; (c) the studies had to have incorporated a qualitative methodology.

The exclusion criteria used to eliminate studies during the initial screening included studies that (a) were not published in scholarly journals; (b) were not doctoral dissertations; (c) were theoretical papers; (d) did not include an apparent methodology; (e) were quantitative or mixed-method studies.

Doctoral dissertations were included in the criteria adding to a complete representation of the findings. Very few qualitative studies existed when filtered through the criteria mentioned earlier which led to the inclusion of doctoral dissertations. The construction of a dissertation committee and the level of scrutiny that doctoral dissertations are subjected to, lead to the acceptance of doctoral dissertations as a valid source for additional detail about the issue being explored. Paterson et al. (2001) suggest that dissertations "must adhere to the standards of academic rigor required by universities, whereas published reports may be more specifically shaped by editorial policy" (p. 36).

The researcher conducted a search for studies using EBSCO Academic Search Complete, Proquest Dissertations and Theses, Educational Resources Information

Center's (ERIC), and Google Scholar. Search terms were used to find as many scholarly, peer-reviewed studies "related to the objectives of the systematic review and the inclusion and exclusion criteria" as possible (Saini & Shlonsky, 2012, p. 102). The terms included: (a) "understanding" "acceptance" AND evolution; (b) "evolution" "natural selection" "biological evolution" AND college students OR post-secondary (students); (c) perceptions of evolution AND college students OR biology majors OR biology courses OR science courses. Once a list of studies began to grow, bibliographic information was also reviewed to find additional studies that fit the inclusion and exclusion criteria.

The preliminary search yielded many studies related to college students understanding and/or acceptance of evolution. A Microsoft Excel spreadsheet was created to organize studies collected in the preliminary search. This spreadsheet included information about each study such as, year published, study methodology, research population, and results. This spreadsheet contained information on 75 studies that would be evaluated based on the inclusion and exclusion criteria. Originally, it was decided to exclude studies outside of the timeframe of 2000-2018 and exclude studies conducted outside of the United States. Of this list, only five studies fit the inclusion and exclusion criteria. To expand the richness of the topic being explored, the date of publication timeframe originally used was expanded to studies published between 1995-2018 and the use of studies that incorporated participants outside of the United States was also added. This resulted in three more studies meeting the inclusion and exclusion criteria totaling eight studies.

The researcher located as many studies that fit the inclusion and exclusion criteria as possible. Guba and Lincoln (1985) stated that qualitative research integrates purposeful sampling "to the point of redundancy" so that "sampling is terminated when no new information is forthcoming from newly sampled units" (p. 202). All material collected for possibility of inclusion in this study and the original search articles were maintained in an Excel spreadsheet and categorized based on the method of the study, participants of the study, date published, and the journal the study was published in.

Of the eight published studies that fit the inclusion and exclusion criteria, 4 came from journals with a quartile ranking of 1 (these are the top 25% of journals in a particular field) and 2 studies had a quartile ranking of 3 (among top 75% of journals). To quantify the level of research activity from which the dissertations emerged, the researcher used the Carnegie Classification of Institutions of Higher Education. According to the Carnegie Classification, both universities were within the highest ranking group for very high research activity.

The small sample size obtained by the researcher was a concern moving forward with the study. However, support for small sample sizes was provided by Major and Savin-Baden (2010) who explained that it is "critical to include a sufficient number of studies to allow for analysis," however having too many studies could make analysis impossible (p. 110). In their experience, Major and Savin-Baden (2010), found "that between six and ten studies is the optimal number" (p. 110). Although the extensive search yielded few studies, the researcher reserved the right to add new studies if found in

the time this research was conducted. Any addition of a study is supported by the emergent nature of the meta-synthesis methodology.

Data Analysis

With the selection of studies that fit the inclusion and exclusion criteria, the studies' findings were identified and assessed for credibility. Credibility of findings was determined by the context of the findings and if the findings were supported by clear data. The next step in the metasynthesis process was of comparing studies and identifying themes.

> Each of the selected papers should be read through in order to record the details of the study including the setting, participants, notions of validity and positioning of the researcher as well as to identify the main concepts. (Major & Savin-Baden, 2010, p. 58)

Reading the studies thoroughly also allows the researcher to deconstruct the studies and identify findings, related to the research question, that are supported by evidence (Major & Savin-Baden, 2010).

The researcher utilized the findings to extract themes across studies. "The outcome of repeatedly reading while identifying metaphors, concepts, terms and phrases should generate a collage of comparable themes resulting in the emergence of a synergistic picture of the phenomenon" (Aguirre & Bolton, 2014, p. 286). Once a list of themes was extracted, examining the related themes across studies and identifying findings that only appear in one study occurred and is described as the "first order themes" (Major & Savin-Baden, 2010, p. 63).

Once the researcher analyzed the findings qualitatively to extract patterns across studies, the researcher synthesized the individual first order themes to derive second order themes (Major & Savin-Baden, 2010). Using the pre-existing themes and categories across the studies the researcher developed a new perspective or view of the issue (Major & Savin-Baden, 2010). Second order themes, along with the first order themes are used to review patterns and "ensure that iterative cycles of interpretation occur" (Major & Savin-Baden, 2010, p. 67).

Provision for Trustworthiness

Within the scope of qualitative research, establishing trustworthiness of the qualitative research can be defined using many terms. Guba (1981), for example suggested four major concerns related to trustworthiness and how they apply to qualitative research. Truth value involves testing the credibility of findings with various sources. Applicability or transferability as related to qualitative data "does not attempt to form generalizations that will hold in all times and in all places, but to form working hypotheses that may be transferred from one context to another depending upon the degree of "fit" between the context" (Guba, 1981, p. 81). Consistency becomes complicated in qualitative research due to belief in multiple realities, particularly when working with humans as the instrument (Guba, 1981). "The concept of consistency implies not invariance (except by chance) but trackable variance – variance that can be ascribed to sources" (Guba, 1981, p. 81). Lastly, neutrality is viewed differently in qualitative research due to the understanding of multiple realities and the role the researcher can play when used as an instrument. Guba (1981) states that this difference

involves “shifting the burden of neutrality from the investigator to the data, requiring evidence not of the certifiability of the investigator or his or her methods but of the confirmability of the data produced” (p. 81).

These terms may support some forms of qualitative research methods, but not all qualitative methods available. This meta-synthesis study used empirical qualitative studies gathered from peer-reviewed journals and doctoral dissertations. Prior to the selection, the researcher made clear the selection inclusion and exclusion criteria and only considered research published in high quality journals. Providing clear reasons for including or excluding a study as part of the data collection process provides credibility to the meta-synthesis study.

Creswell and Miller (2000) discuss the use of triangulation as a validity procedure for qualitative inquiry. “As a validity procedure, triangulation is a step taken by researchers employing only the researcher’s lens, and it is a systematic process of sorting through the data to find common themes or categories by eliminating overlapping areas” (Creswell & Miller, 2000, p. 127). A second validity procedure provided by Creswell and Miller (2000) is researcher reflexivity. This validity procedure involves the researcher self-disclosing their assumptions, beliefs, and biases that may shape their inquiry (Creswell & Miller, 2000).

Tracy (2010) sums up the practice of self-reflexivity, transparency, and data auditing into the end goal termed sincerity. Similar to Creswell and Miller (2000), Tracy (2010) stated that “researchers can practice self-reflexivity even before stepping into the field through being introspective, assessing their own biases and motivations, and asking

whether they are well-suited to examine their chosen sites or topics at this time" (p. 842). Transparency and the use of data auditing add to the sincerity of the research and allow other researchers to use the outlined procedures to obtain similar findings when researching under the same conditions. "Transparent research is marked by disclosure of the study's challenges and unexpected twists and turns and revelation of the ways research foci transformed over time" (Tracy, 2010, p. 842).

To ensure trustworthiness of the findings, the researcher stated, with necessary detail, the data collection and data analysis procedures as well as the categorization choices made during the presentation of the results of this study. The researcher is a tool during this meta-synthesis study and disclosed biases and values within this study. The use of quality empirical peer-reviewed studies added to the credibility of this meta-synthesis. All of those procedures added to the trustworthiness of this meta-synthesis study, which is to explore and analyze postsecondary students' perspectives towards accepting and understanding evolution.

Summary

This chapter provided a description of the qualitative meta-synthesis method for research as well as a framework for collecting and analyzing the data for the study. Also, this chapter described the role of the researcher and provisions of trustworthiness within the study.

CHAPTER IV

Findings

Introduction

After an initial search of the current research involving post-secondary students' perceptions toward acceptance and understanding of evolution, a total of 75 studies were collected before the researcher concluded that an exhaustive search had been made. During the initial search, the researcher continued searching for possible studies until saturation concerning the topic was reached. The 75 studies were than screened using the inclusion and exclusion criteria stated in chapter three, resulting in a total of eight studies that met all criteria.

This chapter outlines the findings in a three phase process. The first phase presents a descriptive synopsis of the eight studies that were selected through the inclusion and exclusion screening process, grounding the information that was gathered during the meta-synthesis process. During the second phase, patterns were extracted from the original studies and synthesized into first and second order themes (Aguirre & Bolton, 2014, p. 288). The last phase in this section took the second order themes found in this study and connected the information to current literature on the topic of students' perspectives towards accepting and understanding evolution.

The first patterns observed from the eight selected studies were termed *first order themes*. Once the first order themes were constructed, the researcher merged or condensed specific themes that appeared to have a strong connection. Some themes ultimately described similar topics and together these themes formed a larger pattern that was stronger than if presented individually. The final arrangement of the first order themes was defined as second order themes.

The *second order themes* are used as section headings within this chapter, followed by the first order themes that collapse into the category. For each of the first order themes, textual support from the eight studies was included to provide the foundation in which the patterns emerged. The inclusion of textual support from the individual studies grounded the first and second order themes during the meta-synthesis process.

The final phase of the meta-synthesis process involved explanation and discussion of the second order themes extracted from the present study as they related to relevant literature. The second order themes were used as a tool to revisit information presented in current literature and compare the patterns observed within the eight selected studies to other pertinent studies on the topic of students' perceptions toward acceptance and understanding of evolution.

Phase I: Descriptive Synopsis of the Studies

Eight studies met the inclusion criteria for this study. All participants in the eight studies were undergraduate and graduate students enrolled in post-secondary institutions. One study included participates that recently graduated from a biology program. Each

study, in some way, addressed students' perceptions toward acceptance and understanding of evolution. All eight studies also utilized a qualitative research design.

Two of the studies specifically addressed religion and learning evolution in the context of an introductory biology course. These studies explored how an evolution module influenced students' perceptions of the relationship between evolution and personal religious beliefs (Barnes et al., 2017a; Troung et al., 2018). Three studies examined the existing perceptions of evolution students bring to the class and how that influenced their thoughts on evolution and scientific theory (Dagher & BouJaoude, 2005; Hokayem & BouJaoude, 2008; McQuaide, 2006).

Included in the eight studies, three studies looked at specific groups of students, American Muslim students, biology majors from Lebanon, and biology majors attending a Christian university, and their understanding of evolution (Fouad, 2016; Dagher & BouJaoude, 1997; Winslow et al., 2011).

Barnes et al. (2017a). This study examined "student perceptions of compatibility of religion and evolution" before and after a two-week evolution module (p. 105). The authors were also interested in students' comfort level and appreciation level of discussing religion in the module. Students' religiosity was determined to see if the module had differing effects on religious and nonreligious students. Students included in this study were mostly first-year students and were enrolled in an introductory biology course at a large public university located in the southwest United States during the time of the study.

Materials included in the course module were chapter readings on natural selection and speciation, a handbook addressing evolution and religion, and meetings with guest speakers discussing the relationship between religion and science research. Students also participated in activities surrounding deep time and old Earth, simulations on natural selection and debates on the pros and cons of evolution theories.

Before and after the two-week module, students answered the following question, "In a few sentences, briefly describe your views on the relationship between religion and evolutionary theory" (p. 107). Student discomfort or appreciation for the module was evaluated using content analysis and grounded theory. Students' religiosity was measured based on how the student perceived religion as salient to their identity and to the extent the student participated in religious activities.

Of the 60 students that took the pre-module survey, 32 students stated a perceived conflict between religion and evolution. Eleven of those 32 students with a perceived conflict changed their stance at the end of the module. Fifteen students, of the original 60, were unclear of their perceived relationship between religion and evolution with 8 of the 15 changing to a perceived compatibility between religion and evolution after the module. No student that began with a stance of no conflict changed to unclear or a perceived conflict throughout the module. Also, no student shifted from unclear at the beginning of the module to a perceived conflict at the end.

After analyzing the post module survey, the authors reported 40 students stating they appreciated at least one aspect of the module that discussed the relationship between religion and evolution. Of the 25 students classified as religions, 15 were relieved that

both religion and evolution can be incorporated into their lives. Thirty-five students were classified as non-religious and 25 students from this group tended to say "that they found it reassuring to know that one could hold religious beliefs and yet not let it affect their views on science" (p. 109). All students maintained their religious beliefs or non-religious stances throughout the module.

The authors indicated that "discussions about religion and evolution affected not only religious students' perceptions of the relationship between religion and evolution but also the perceptions of nonreligious students" (p. 109). The intention of the authors was to provide religious students who perceive a conflict between evolution and religion with a method to visualizing how evolution and religion can be compatible, but they were surprised to see non-religious students' perceptions shift to compatibility.

The post module student responses led the authors to see a pathway for students in the study to relay their knowledge about the relationship of religion and evolution to others, such as successfully teaching the subject of evolution to individuals with various beliefs, or having conversations about evolution with people with differing viewpoints. The authors also expressed helping "nonreligious students challenge their own negative stereotype about religious individuals in biology, which could possibly ameliorate a lack of religious diversity in biology" (p. 110).

Truong et al. (2018). The research conducted in this study was performed by two authors who also collaborated on the study previously discussed. However, the first author was not included as an author of the previous study. The authors took the results and information gained from the previous study and addressed some of the limitations

that appeared. An introduction identifying a potentially contentious relationship between religious beliefs and evolution was provided to the students prior to introducing information about evolution. The intentions of this study were to better understand what parts of the introduction were most influential when presented to religious students, while reducing the amount of time it took to present the information.

During this study, the authors limited the introduction to six minutes of communication about evolution to religious students who might perceive a conflict between religion and evolution. Qualitative analysis of student reflections and in-depth, semi-structured interviews were used to investigate the extent to which introductory evolution instruction decreased students' perceived conflict between evolution and religion and what aspects of the overall instruction were important for reducing perceived conflict.

This module was included in a summer bridge program for incoming, first-year undergraduate biology students during a summer introductory biology course at a large public university in the Southwestern United States. The module provided to the students focused on natural selection and speciation. Thirty-four first year undergraduate biology majors completed an open-ended student reflection before the evolution module. Fourteen students expressed a perceived a conflict between their religious beliefs and evolution. Ten of the students that had expressed a perceived conflict agreed to be interviewed to discuss any reduction in perceived conflict and what aspects of instruction influenced this change.

The authors noted that, “eight out of the ten students who perceived a conflict before the evolution module decreased their level of perceived conflict after the evolution module, and two students showed no change in their perceived conflict” (p. 110). No student had a higher level of perceived conflict between evolution and religion after the module.

Students experienced varying level of perceived conflict between evolution and religion after the module. For example, some students showed “decreased conflict between evolution and religion while maintaining their religious beliefs” (p. 110). Some students had a greater reduction in perceived conflict and accepted the major aspects of evolution; however, “some of their statements indicated that they may still perceive a small amount of conflict with evolution in other ways” (p. 110).

After analyzing the student interviews, the authors identified eight distinct aspects in the short evolution introduction or the overall module itself that reduced students’ perceived conflict between religion and evolution. The authors felt that information gained from this study added to results from the Barnes et al. (2017a) study (referenced previously) in that the current study expanded knowledge of “specific aspects of the evolution instruction that these students thought were important for reducing perceived conflict with evolution” (p. 113). The authors noted that in previous studies, there have been weak correlations between increased understanding of evolution and student acceptance of evolution. In response, the authors stated that perhaps “increased exposure to evolution content is effective for decreasing perceived conflict with evolution only in the presence of ReCCEE [introductory] practices” (p. 113).

Dagher and BouJaoude. (2005). This study focused on expounding students' conceptions of the nature of science as a vehicle for understanding epistemological foundations of evolutionary theory. Specifically, the authors stated the purpose of the study was "to explore how some college biology seniors characterize the nature of evolutionary theory" (p. 379). In construction of the theoretical framework of this study, the authors described differences between defining a scientific concept as theory or law. With the complex nature of evolutionary theory outlined by the authors, the interest of the study was "finding out how college biology students characterize the nature of this [evolutionary] theory, why they think it is called a theory, and to elicit in the process comparisons with other scientific theories that they choose to discuss" (p. 382).

Fifteen students were interviewed from a group of 62 college biology majors enrolled in a senior seminar at a private university in Beirut, Lebanon. The selection of students was purposefully based on a response to an open ended question related to the students' perceived relationship between religion and evolution. Students selected represented a wide range of views and religious backgrounds. With the use of the original survey, the researchers continued with follow up questions pertaining to evolution and its status as a scientific theory. Five themes were defined from the transcripts that the authors felt captured students' characterizations of evolution as a scientific theory.

Of the fifteen students, the majority focused on the nature of science and the need for large amounts of evidence that clearly led to the same results. Students felt that this was required for evolutionary theory to be "proven". One student stated that evolution

was impossible “because [evolution] describes mechanisms that extend over thousands and millions of years that cannot be measured on human scale” (p. 383). Other students highlighted the “importance of direct evidence and explained that it meant observing the process of evolution in person, something they knew to be impossible due to the time frame involved” (p. 383). Some students were aware that evolution could be observed and experimental data existed related to evolution, but that this data could not support the claims of macroevolution.

Students’ ability to explain differences between theories, laws, and hypotheses varied and lacked a clear foundation when used in the scope of evolution. One students’ view was that “theories are not scientific enough because: ‘something is scientific when I don’t have to doubt it. A theory is something that may be right and may be wrong” (p. 384). Students struggled accepting evolution as a theory, particularly when it concerned human evolution, because “we cannot experiment [evolution] on humans” (p. 384). The necessity for direct experimentation became a focal point for students and they felt that “the theory of evolution falls short of this standard” (p. 384) because the amount of direct observational data they believed to be available did not meet the saturation limit for becoming a theory. Some students do recognize historical evolutionary data, however, they still emphasized the need for experimentation in a lab setting.

One of the lesser expressed themes was the idea of predictability. One student struggled accepting evolution as a complete theory because of “scientists’ inability to predict the course of evolution” (p. 386). A deeper understanding of the nuances of evolution, such as differing genotypes within a population, and unpredictable

environments, could potentially mitigate the students' concern with the unpredictability of evolution.

As a whole, Dagher and BouJaoude (2005) inferred that the students had constructed a "generic" model of theories in physical science that they were using to "gauge the credibility of the theory of evolution, leading most of them to conclude that it is not truly scientific" (p. 386). The authors mentioned two concerns related to this shallow "generic" understanding of theories. First, the authors highlighted the development of students' scientific knowledge in their K-16 schooling as a foundation for the ideas of scientific theory they hold.

Secondly, most students interviewed felt that evolutionary theory is defective particularly when some aspect of evolution clashed with their personal religious beliefs. The unwillingness to question their religious beliefs and the shallow understanding of the nature of science guided the students in their ultimate disagreement with evolution being considered a strong theory.

Dagher and BouJaoude. (1997). Dagher and BouJaoude (1997) prefaced this study by describing inquiry in science learning as being subject to various factors that can be rooted in culture, beliefs, values, and emotions. This aligned with other author's ideas in which a students' worldview will influence what they consider to be important during the learning process and conceptual development. Dagher and BouJaoude (1997) expressed that Darwin's Origin of Species challenged the prevalent Judeo-Christian worldview of a constant world created by a wise benign creator. Darwin's theories also challenged some religious accounts in the Moslem faith and the holy Qur-ān.

The purpose of this study was to understand how students managed their understanding of the theory of biological evolution given their different religious backgrounds. The authors employed two main research questions to guide their study: "(a) How do students accommodate their religious beliefs with their understanding of the theory of biological evolution? and (b) What arguments do they present to justify the positions they espouse?" (p. 432).

The participants of this study were biology major undergraduates enrolled in a senior seminar course at a private university in Lebanon. Not all students had taken an evolution course prior to this course as it was not a requirement for the biology program. Sixty-two students participated in a questionnaire during the beginning of the course. Of this group, fifteen students were chosen to continue with an interview to clarify and elaborate on their answers. Students' religious beliefs encompassed seven major Christian and Moslem sects.

Personal beliefs varied among the students concerning evolution. Students expressed either an acceptance of evolution based on scientific evidence or acceptance of evolution while holding religious beliefs and keeping the two components separate. Some students did not agree with evolutionary theory because it was incompatible with their religious teachings, or rejected evolution because they did not believe there was enough evidence in favor of the theory. Other students attempted to find a compromise between evolution and their religious believes in an effort to reduce their perceived conflict. There were also students unwilling or were confused on the details to the point that they neither accepted nor rejected evolution.

The authors assigned four categories describing students' personal beliefs towards evolution (for evolution, against evolution, compromise, and neutral) and narrowed the seven religious sects that students belonged to into two groups (Christian and Moslem). "Lebanese Christian students are more willing to consider a nonliteral interpretation of the Bible, which in turn allows them to adopt more reconciliatory views than their Moslem peers for whom the Qur-ān is the ultimate authority" (p. 436).

When analyzing the four themes associated with objection to evolution, which included conceptual difficulties, alternative interpretations, nature of science, and nature of religion, the authors considered them to be intricately connected to students' religious beliefs. "The religious worldview does not only govern beliefs about origins or issues of meaning and values. A religious worldview affects beliefs about worldly activities including science and its limits" (p. 437).

Students who rejected evolution insisted that there should be 100% proof that evolution is true, including having direct observations and replication. Dagher and BouJaoude (1997) expressed, "…because macroevolution is not directly observable, some students are reluctant to accept the whole evolution story" (p. 438). The authors stated, "given their need for direct evidence for speciation and their belief that scientific knowledge changes while religious knowledge does not, students who rejected the theory did so on the basis of what appeared to them to be strictly rational ground" (p. 438).

Dagher and BouJaoude (1997) concluded with two recommendations. The first recommendation centered on students' understanding of the nature of science facts, laws, hypotheses, theories, and evidence in all science topics. The authors stated "much of the

confusion that appears in the evolution/creation debate arises from confounding the everyday with the scientific use of these terms" (p. 439). The authors also understood that students' learning fits in with their preexisting attitudes and beliefs. They highlighted that "students' values and beliefs may have to be discussed before and throughout instruction, but they cannot be ignored or dismissed" and that "the purpose of such discussions is to clarify concepts, beliefs, and conflicts without pressures to convert any party to any one belief about either science or religion" (p. 441).

Winslow et al. (2011). The direction for this study was to "explore the process through which Christian biology-related majors at a Christian university sought reconciliation between their understanding of evolution and personal religious beliefs" (p. 1026). To contextualize this process, the authors addressed several concerns surrounding the instruction of evolution. This included issues such as providing students with a solid understand of the nature of science, respecting individual's beliefs and how they may influence the learning process, and addressing students' ability to understand evolution without accepting all the tenets of evolution.

The focal population for this study was students that held creationist views at some point in their life, which brought awareness to the authors that, "the persons whose religious beliefs are in apparent conflict with evolution may actively resist learning about evolution" (p. 1028). Students may question evolution's credibility, they may take the words of Genesis literally, and they may question what God's role is in nature when accommodating evolution. Participants were seniors or recent graduates who had completed an upper-level biology course on evolution.

The primary researcher was clear about their biases and personal views concerning evolution to the reader. The primary researcher expressed that they were highly suspicious of biological evolution throughout their time in college. They also stated that, "prior to conducting this study, they came to accept evolution through reading a number of books written by Christian scientist and interacting with colleagues at the study site who served as examples of Christians who affirmed evolution" (p. 1030).

The question, "How do Christian biology-related majors at a Christian university reconcile evolution and their personal religious beliefs?" (pg. 1029) guided this study. A socially constructed knowledge framework was utilized during this instrumental case study design. The selected site of this study was a Midwestern Christian university with an undergraduate enrollment of 1,200 students. A purposeful sampling method was used to select 15 seniors and recent graduates (within the last two years) from biology-related majors. All students selected had completed an upper-level course on evolution. At the point of this study, 13 of the 15 participants believed in Theistic evolution, which differed from a belief in Young Earth Creationism during their childhood (14 of the 15 participants).

The researchers collected semi-structured interviews along with student assignments, surveys, and field notes as data during this study. After interviews were transcribed and reviewed by the participants, the data was coded. "The development of codes in the first reading of both interview transcripts centered on participants' views of creationism and evolution as well as the influences and events that fostered those

perspectives" (p. 1031). With additional readings, themes and subthemes emerged that were organized into three categories based on their similarities.

The first category included different influences on participant's views of creationism and evolution. For example, participants felt anxious about their parents' potential reactions if they did accept evolution. All participants were clear that their parents were major influencers of their own personal beliefs. "Many participants reported their parents actively pressured them to reject evolution" (p. 1035). Participants expressed a positive influence from professors who incorporated evolution into a Christian context, and did not isolate the two.

The second category related to views on the domains of science and religion. Within science, students valued the peer-review process, verification through replication, observable evidence, and learning how to ask questions. Most of the participants maintained boundaries between science and religion, but would combine their understanding from both to create a larger picture. The participants desired a positive relationship between science and religion, one in which science and religion could co-exist.

The third category examined participant's reconciliation of evolution and personal religious beliefs. The majority of students accepted human evolution on one of the surveys administered, even though in other data sources they had mixed feelings toward the topic. Participants expressed that coming to accept evolution was a slow process and was a "tug-of-war" between their ideas about evolution and personal religious beliefs. Although the participants were slowly becoming more accepting of evolution, many felt

that the "scientific findings merely reinforced their greater respect for God's creative abilities" (p. 1045).

Hokayem and BouJaoude. (2008). Within this study, the authors explored how students perceived evolution after taking a course in evolution. Specifically, the authors examined students' epistemological beliefs about science, worldview presuppositions of causality and nature, and their religious beliefs. Evolution from the point of view of the instructor teaching the evolution course was also included in the study. The reasoning was to compare students' worldview about evolution with that of a scientist teaching the course.

Eleven junior and senior college biology students enrolled in an evolution course at a university in Beirut, Lebanon along with the professor teaching the course participated in this study. The participants belonged to Christian and Moslem religious groups. Participant data was collected using questionnaires and semi-structured interviews. Prior to the completion of the course the students and instructor were interviewed in depth. The interview including discussion of the participants' position regarding evolution, views on religion and science, epistemological beliefs, and clarification of any misunderstandings from the questionnaire.

The data was used to create emerging themes that were organized in to five categories: (1) perception of theory of evolution, (2) perception of religion and science, (3) epistemological beliefs about science, (4) perception of nature, and (5) perception of causality (p. 402). The data was re-reviewed several times and "recurring ideas were then

used to recode the data to identify the position of each student in each of the five categories" (p. 402).

After analyzing the data, students were classified into three categories: those who accepted the theory of evolution completely, those who were uncertain, and those who rejected the theory. For the first category, students that accepted evolution had similar views regarding "the tentativeness of science and the necessity of concrete evidence" (p. 405). When discussing religion and science, these students either considered science and religion as independent or that there was a conflict between science and religion and scientific explanations were more valid. This group of students perceived some sort of order to nature and also "accepted that theory of evolution demonstrated preference for scientific causality" (p. 406).

Students who were uncertain of evolution felt the same as those who accepted evolution about science and the need to have concrete evidence. However, these students did not believe that there was concrete evidence to support evolution. These students varied in their perception of whether science and religion were independent or that they were conflicting.

Only one students that participated in this study rejected evolution completely. The student indicated that this was not due to their religion, but the skepticism in the evidence that was provided in the evolution course. This student did consider their religious beliefs to be very strong and that science and religion "go together" and "were not in conflict but were complementary" (p. 407). The student did use scientific reasoning when discussing causality.

The instructor of the evolution course preferred only using scientific and evolutionary explanations during the course; however, their preference for science did not make them an atheist. They acknowledged the difficulty for individuals to analyze their religious beliefs and acceptance of evolution during the evolution course. The instructor stated:

> The implication there [accepting evolution] might frighten people, because all the bits and pieces which the theory is made up of they're quite clear, there's no argument about the validity of all of this but the implication might frighten people because it means there is evolution (p. 409).

The students and the instructor both highlighted potential difficulty in accepting evolution; however, the instructor did not doubt evolution "unlike students who perceived those difficulties as legitimate reasons to reject the theory of evolution" (p. 410).

Fouad. (2016). According to Fouad (2016), "This study explores the relationship among American Muslim college students' religious beliefs and their ideas about biological evolution" (p. 1). Before exploring this question, the author addressed various learning gaps in science that individuals of differing cultural backgrounds encounter. This included: teachers lack of skills dealing with diverse students, teachers ignoring differences in students' culture and beliefs, and disconnections between a students' home life and school life.

This study specifically explored American Muslim students' relationship between their region and ideas about evolution. Student participants ranged from freshmen to senior post-secondary students enrolled in various universities and included students born

in the United States and student who immigrated to the United States. It should be noted that all Muslims, regardless of sect, follow the Quran. However, disagreements occur over the traditions considered authentic and to be used during religious rulings.

> Many Muslims have no problem accepting evolution as it relates to any other living thing besides human beings, but do not believe that human beings evolved from a common ancestor of another animal. One reason for this is that the Quran does not specify how those other living things were created, but it does specify how Adam was created (p. 10).

The participants of this study were asked to participate after being approached by the researcher at various Islamic conferences. Additional participants were obtained by snowball sampling. Sixty undergraduate students participated in this study from various Muslim sects (Sunnis, Shias, non-specific Muslim, Ahmadis, Spiritual (no longer Muslim). Data was collected using structured and semi-structured interviews and written surveys.

After examining surveys and interviews, the author categorized participants into three groups. "One position is that evolution happens and that God directs the process" (p. 102). The author referred to this as the theistic evolutionist position. "The second position is that evolution occurs for all species except human beings and God directs the process of evolution and is also responsible for the special creation of human begins" (p. 102). This position is referred to as the belief in special creation of humans. "A third position is that all species are specially created, and that God is responsible for this process" (p. 103). This position is referred to as a belief in special creation of all species.

Participants who were part of the theistic evolutionist position were placed there for a couple of reasons. Either the participant was "convinced by the scientific evidence that evolution happens and they do not see any evidence in the Quran that contradicts this" (p. 108) or God's attributes make it possible for organisms to evolve under divine direction. In all cases, these participants believed that evolution is compatible with religion. These participants also scored lower overall in terms of religiosity.

Participants who held that humans were specially created while other species evolved highlighted that the Quran specifically describes the creation of human beings. This was interpreted to mean that humans were specially created. Other species' creation is not specified in the Quran, allowing these participants to consider the possibility of evolution. Some individuals within this group stated that evidence for human evolution was not strong enough, while others accepted the evidence for human evolution but believed that their religious beliefs outweighed the evidence provided for human evolution.

The last group of participants held the position that all species were specially created. This was based on their religious beliefs. Some of these participants accepted the ideas of microevolution, but generally used the term 'adaptation' for the process. Participants with high levels of religiosity held the belief in special creation of all species.

After comparing survey answers and interview questions, the author found that for this study, "those that accepted macroevolution for all or most species were more likely to have either an excellent or good understanding of evolution than those who rejected macroevolution for all species" (p. 219). After the completion of this study, the

author suggested discussing natural selection in terms of microevolution in the classroom before introducing macroevolution, as well as helping students understand nature of science concepts, such as scientific theories and validity of observationally based theories (p. 234).

McQuaide. (2006). McQuaide (2006) conveyed that "the purpose of this study was to document prescientific concepts and examine the processes of conceptual change involved in development of an understanding and acceptance of the scientific theory of biological evolution in first and second year college level biology students" (p. 9). Prescientific concepts were defined by the author as "preconceived ideas that are contradictory to well-established and accepted scientific concepts" (p. 9). It was suggested that individuals can form preconceived ideas from family members or earlier teachers. McQuaide (2006) suggested that for a conceptual change to occur an individual must be dissatisfied with an existing concept and replace the concept with new information that may conflict with what had existed.

McQuaide (2006) conduced a phenomenological investigation into undergraduate understanding and acceptance of scientific theories, including biological evolution. The author recorded and analyzed student descriptions of conceptual change followed by the use of a survey to select seven participants to interview. Participants were undergraduate science major students in a small Southern Baptist-affiliated liberal arts school located in south central Kentucky. Participants were enrolled in Biology classes as the time of the interview and received a high score on a MATE (Measure of the Acceptance of the Theory of Evolution) survey, which quantified the level of acceptance an individual holds

of evolution. A higher MATE score (>70) indicated a greater understanding and acceptance of evolution. The participants selected for the interview scored between 73 and 92 on the MATE survey.

The interviews allowed the author to gain information about the base knowledge participants used to support their understanding of biological evolution and other science concepts. Information that influenced participant's knowledge on evolution varied considerably and included statements pertaining to topics such as: fossil records, age of the earth, survival and adaptation as described through Darwinian Natural Selection, continental drift, religious beliefs, difficulty understanding complex topics pertaining to evolution and embryological development. Although the participants mentioned various topic that they perceived as supporting their knowledge of evolution, many of the students could not connect these concepts to each other (p. 111).

The author noted that for a student to experience a conceptual change about evolution they first had to weaken previously held religion beliefs. Participants also described applying logic and reasoning to science content when discussing conceptual change. "Findings of this study indicated that acceptance of science concepts occurred by weighing evidences and selecting the more appropriate idea" (p. 88). The author highlights that often the participants understanding begins with small portions of a whole. "Understanding and accepting biological evolution as a whole often occurs in small incremental steps. And it requires that long-held, non-scientific beliefs be replaced incrementally with new information" (p. 112).

Phase II: Extraction of First and Second Order Themes

The mention of students' religious beliefs as it influenced understanding of evolution was transparent in each study either by direct statements within the findings of the original studies or by indirect interpretation by the researcher. The relationship between a students' religious beliefs and the influence their beliefs had on understanding and accepting evolution was nuanced in many ways within the studies examined. Some students professed their stark rejection of the processes of evolution as a result of their religious teachings. Other students felt that their religious beliefs and acceptance of evolution do not conflict, but can co-exist to answer different questions. A theistic evolutionary approach was used by some students, in which the understanding of evolution was accepted by the student if the overall processes of evolution were dictated by a divine being. Lastly, some students grappled with their understanding of evolution in light of their religious beliefs, and struggled with a possible betrayal of their faith, or family teachings, as they continued to learn and understand various evolutionary processes.

The various combinations of how students work through their understanding and acceptance of evolution in light of their religious beliefs was witnessed in all studies included in this meta-synthesis. No study used during this meta-synthesis involved a participant group that comprehended evolutionary processes in the same way, or held religious beliefs that influenced their understanding of evolution in the same way. Although the researcher grouped student responses into a limited number of categories, the process by which a student comes to understand evolution is specific to that students'

personal beliefs, culture, experiences, and learning techniques. It should also be noted that the responses from students, related to learning evolution, are specific to a particular moment in the students' lives, and may or may not change throughout their career as post-secondary students.

The initial patterns observed by the researcher, during the first analysis of the eight selected studies, were termed first order themes and were guided by the following research questions:

1. What perceived conflicts do post-secondary students face when learning about evolution?
2. Based on post-secondary students' perspectives, how do personal religious beliefs influence understanding and accepting evolution?

The first order themes were observed specifically from student quotes included in the original eight studies. Interpretations provided by the researchers from the original studies were used sparingly as textual support for the first order themes. As previously stated in the introduction of this chapter, the major headings within the following section designate the second order themes, with the first order themes that together support the second order themes listed and described subsequently.

Second-order Theme 1: Students Perceive a Conflict Between Religion and Evolution

The following first order themes emerged as patterns related to why a student perceived there to be a conflict between their personal religious beliefs and the topic of evolution.

First Order Theme 1a: Students Explain Change in a Species Using Religious Belief. At the time that the studies selected were conducted, some students firmly grounded all scientific learning within the scope of a divine being. The educational timeframe for each student in those studies varied. Students may have completed courses that included the topic of evolution, while others may have been entering science/evolution courses for the first time in a secondary education setting. It is also unclear to what extent individual students were provided information about evolution prior to their secondary education experience.

When questioning students on their opinion to the following statement, "Evolution is a good explanation of how new species arise," Fouad (2016) reported that one student expressed "Allah created each and everything. I don't think evolution has a role in it. I don't think the whole new species can be created through evolution. I think its Allah who creates it" (p. 104). In this same study, students felt that science could not answer all questions and thus relied on their religious beliefs to answer questions they perceived that science cannot. This method of answering deeper questions, related to science, was illustrated by the following student statement, "There is a big gap in science. How did something come from nothing? It's a gap they try to fill up with reason, but it's God, not science" (Fouad, 2016, p. 183). A student comment from Dager and BouJaoude (1997) echoed the previous statement when they indicated,

> It's not that I reject the theory of evolution completely … but all elements which are probable but not yet proved by science I discard and personally recur to the

> explanations offered by my religion because man is not only a body and a brain, he is also a spirit with beliefs.

Students who hold a firm religious belief, and a credence in the literal interpretation of religious text, may experience increased conflict when learning about evolution upon entering a post-secondary institution. Winslow et al. (2011), for instance, expressed that participants learning evolution "recognized that a literal interpretation of Genesis was at odds with evolution" (p. 1042). Students entered post-secondary institutions with various attitudes on the relationship between identifying as a religious individual and accepting evolution. One student remarked, "I have been taught my whole life you can't be both [a Christian and an evolutionist], that's just not how it works" (Winslow et al., 2011, p. 1035).

One student used personal religious beliefs as a tool to show that evolutionary processes have not occurred, as well as stating that the beginning of all matter began with a divine being. This student declared,

> Well, I mean, I can't even tell you that I know from the specific verses you can find in the Quran anywhere that says that, but I think that all of life, that not even just on earth, started with Allah, and He is the Almightly, and I don't have like a general source or reason to that. That's just like what I believe, and I don't think that human hands played anything in it. I think that He definitely started it, and that we're a part of it. So like all those things people talk about, like the Big Bang theory and things like that, I don't necessarily believe in those, and even those theories actually still have holes in them, and I think the reason they have holes in

> them is because the truth is, that scientist don't want to say, that Allah is actually the one that started it, which is why they can't find a solid reason to the pinpointing part of when the universe began (Fouad, 2016, p. 197).

First Order Theme 1b: Students Have a Negative View of Scientific Figures. Two studies included in this dissertation presented student statements that highlighted possible struggles in accepting evolution due to negative stereotypes related to evolution and scientific leaders that espoused evolution as an overarching tie between all sciences. One student recalled conversations in their household, such as, "Darwin is the tool of the devil and … he's led so many people astray from God and that's just terrible and don't get sucked into that because it's the devil working through him." The student added that they would announce to friends, "Oh yeah, I can't believe these evolutionist liberals." "Those two words always went together-liberal and evolutionist!" (Winslow et al., 2011, p. 1035).

Another students' opinion proclaimed negative views toward scientific figures, such as Richard Dawkins, after watching online videos and reading text from various scientific figures. This student perceived that Dawkins has "a hatred towards God, and hatred toward religion" (Fouad, 2016, p. 156).

First Order Theme 1c: Students Limited Talking About Evolution Because of Negative Stereotypes Others May Hold of Evolution. Two students from concurrent selected studies felt uncomfortable discussing evolution with others for fear that the stereotypes others held about evolution would create unwanted tension. A particular student described the encounter they ha, with their strongly religious parents after

explaining evolutionary topics they were being taught at their post-secondary institution. This student recalled,

> [the] kind of looks they give me whenever I'm like, 'Well, what about this [evidence for evolution]?' Because I get real kind of built up about things like this … and I'm like, 'But this is what I learned in college' [shouting as she says this] and I bring my papers home and I'm like, 'Look at this' [pounding the table] and they're like a little skeptical … You kind of see it in their eyes and they furrow their brow and stuff like that (Winslow et al., 2011, p. 1035).

Another student felt uncomfortable, in general, talking to anyone about evolution due to anxiety about what stance others held concerning evolution. This student mentioned these moments of potential unease in the following statement, "The only moment I felt uncomfortable was when I didn't know if I was speaking to someone who was firmly a believer in creationism, since my opinions on evolution are strongly for it" (Barnes et al., 2017a, p. 109).

First Order Theme 1d: Students Avoid the Topic of Evolution Due to Conflict or Challenge to Their Personal Religious Beliefs. One study analyzed for this dissertation included student perceptions of evolution coming into direct contention with some aspect of their personal religious beliefs. One student perceived acceptance of evolution as directly impacting a person's morals. This student declared,

> Well I would say that moral consequences of accepting evolution, they can come into play if a person's belief in evolution causes them to reject, which many, a lot of atheists, their way of refuting the existence of God is evolution. I would say

> this can destroy a person's morals, because if they don't believe that there is a Creator they would have no, some, some people would have no reason to believe in right and wrong, no reason to believe that there's consequences for the way that you live your life. This doesn't affect all atheists. There are some, I've known some atheists who are generally good people. They're nice people. They believe in being kind. It's not every single one, but there can be moral consequences through evolution. It's not a blanket, I don't believe it's a blanket statement that affects all atheists or all people who, I guess everyone who believes in evolution is not an atheist, but if you go that route, it can happen (Fouad, 2016, p. 123).

First Order Theme 1e: Students do Not Accept Evolution Due to Influences by Family. Winslow et al. (2011) explicitly addressed that views of evolution held by parents were an important factor in participants' anxiety in accepting evolution. Five students included in this study reported their parents had engaged in "heated arguments with the participants who were in the process of accepting evolution while at the university" (Winslow et al., 2011, p. 1035). Three other participants "evaded conflict with their parents by avoiding any discussion about evolution" (Winslow et al., 2011, p. 1035).

Individual students "reported their parents actively pressured them to reject evolution" (Winslow et al., 2011, p.1035). One student recollected an encounter, with their father, where they cited his comment towards them learning about evolution, "Why are you thinking this way? We sent you off to a Christian school [and] you are learning all this liberal garbage?" This student, as well as five others, "indicated their parents

viewed a literal interpretation of Genesis as a necessary condition for salvation" (Winslow et al., 2011, p. 1035).

Fouad (2016) presented a discussion with one student, who learned about evolution through a religious lens from their family, which "predisposed her to reject evolution despite exposure to convincing scientific evidence in the classroom" (p. 157). This student felt that evolution should not be taught prior to college because,

> maybe at that time you don't have your own set of beliefs, or maybe [you do not have] knowledge on that topic that lets you say otherwise, almost. I mean, I was taught otherwise when I was in high school, because my family, and my background, so I knew that, when we were first taught about the theory, I know that it was incorrect, or something that I didn't believe in our faith. For other people, I do know people who maybe did believe at the time—I don't know if they still do—once we were taught it [evolution], because it makes sense, I guess, the way they presented it (Fouad, 2016, p. 157-158).

Second Order Theme 2: Students Find a Compromise Between Evolution and Their Religious Beliefs.

The first order themes included in this section highlight students' attitudes that evolution happens in some fashion. Students' views included the presence of a divine being as having driven evolutionary processes, a divine being created all living things and then evolution occurred, or a divine being created some organisms, like humans, as we see them currently, while other organisms have evolved over time. Students who espoused these views seemed to be reconciling their new understanding of evolutionary

process with the cultural and religious identities they held. Instead of completely ignoring or disagreeing with either evolution or their personal beliefs, or keeping these two aspects of their life completely separate, students in this category found methods to include evolution into their religious beliefs.

First Order Theme 2a: Students' Accepted Theistic Evolution. Student responses highlighted in this first order theme involved statements that a divine being used evolution as a method for directing change on earth. Several students quoted in Barnes et al. (2017a), Dagher and BouJaoude (1997), Fouad (2016), and Winslow et al. (2011) held a belief that a divine being has allowed for various forms of evolutionary processes to happen. Students' words, provided below, showed examples of a theistic evolution perspective. One student explained their position in a matter of fact way,

> I don't think the theory of evolution contradicts religion. I think it just, I think it enhances it, because I think it's showing that God is not something that just creates stuff and then moves away, but He is directly involved. He makes them change. So, God is, you see God is All-Magnificent and Always Knowing, so to say that God made something and just stepped away like that is to contradict what God's power is (Fouad, 2016, p. 105).

A second students' comment paralleled the sentiment to evolution mentioned above. This student declared,

> The thing is for me, I know some Muslims they feel a bit antagonized by the idea. You know, it's either God or evolution, but for me, I don't see how it's impossible for God to have a part in evolution, have this system sort of play

> through. I know it sounds sort of deistic, maybe, the Clockwork God, but, I mean there's no definitive rejection in the Quran towards that, so I-I don't understand. For me, they seem like two things that could play together: God creating, but also God creating like a system for our evolution, whether it's from apes to humans, whether it's animals evolving (p. 109).

Another student saw no conflict between evolution and their religious teaching. They were very clear, however, that the processes of evolution could not create a new species. They were comfortable that evolution occurred within a species; however, any instance where a new species emerged was not accepted. The students' description below gave more detail to this thought process,

> All of these are examples of adaptation to environment, and I don't see any conflict in scriptures that would say that absolutely not. Like the Bible and the Quran, they're very poetic and a lot of words have different meanings. There's literal and metaphorical meanings, and I don't see a conflict for speciation or adaptation, but there's definitely a conflict for change of kind, because it says in both scriptures that I'm familiar with that God created all of, every kind for its kind to reproduce with its kind, that there wasn't just like three different kinds and then everything branched from those, but it's very specific in scripture that each kind was made individually for its time, but there's no conflict about change of species, like red birds becoming green birds or the beaks changing or the shape of them changing or their functions changing. There's no conflict in the scripture about that. And it doesn't seem nonsensical to me from a logical standpoint either,

> because we do see evidence of change, observable evidence of change in species and things like that, but we don't see change over -- change of kinds. As long as the evolutionary, the standpoint of evolutionists comes up as in push for change of kinds, then it doesn't conflict with my morals or my beliefs or anything like that. As far as I know, there's not conflict with scripture, either (Fouad, 2016, p.137-138).

One student stressed the importance of learning all sciences as a way to understand a divine being. This student specifically pointed out religious verses they considered to be evidence for learning science as a subset of their religion. The student elaborated by saying,

> like I said before, science and religion, science is a subset of religion" "[Science is a subset of Religion] of my religion, or our religion, yes, and I would say the greatest gift that God has given us, the greatest tool that we have been given to use. In fact, in one of the verses, God encourages the believers to seek and learn the universe and study it, and to learn biology, you know. "He who knows himself will know his Lord," which can be translated form my point of view, as understand how your body works, then biology, human physiology, the miracles of your body, and then you understand the work of God (Fouad, 2016, p. 182).

Lastly, one student pointed out that the amount of change that occurred through evolutionary processes may show that the creation of the world was not as phenomenal as is stated in religious text. They expressed this view by saying,

> I tend to believe that religious tales are meant to be understood, not taken literally. Therefore, I find it logical to believe that evolution is a valid theory to explain the appearance of the various forms of life. Besides, admiring the miracles of the existing variety of life, and the complexity of the forms does not contradict, in any sense, the idea of omnipotency or presence of God. It just implies that the beginning of the world or its evolution to its present state, is simply not as miraculous and sudden as religion states (Dagher & BouJaoude, 1997, p. 435).

First Order Theme 2b: Students accept the idea that all species have evolved, except for humans. This first order theme includes student comments from two studies selected for this dissertation. The understanding that organisms have evolved is understood and accepted by the students; however, students state that humans were created by a divine being in the form that is currently seen and no human evolution occurred. Dagher and BouJaoude (1997) provided the following comment from a student,

> I don't go for the theory that man was originated from a lower (inferior) animal, but it seems true that other species could have evolved from a single ancestor. This is, perhaps I can say that I believe in the Aristotelian theory of evolution concerning the view of man's origin (every species evolved from its same ancestor) but I go with the Darwinian theory concerning all the other species (p. 435).

One student perceived that the conflict some individuals have experienced, between accepting evolution and maintaining personal religious beliefs could be narrowed to human evolution only. This student stated,

> I think the main idea where people think it does conflict is about humans, and where humans originated from. If I just keep in my mind that God created Adam and Eve and that was the start of humans, then I can just keep believing in my faith and also believe in evolution while seeing the changes within the species of animals and humans (Fouad, 2016, p. 184).

Another student found evidence in religious text to convince them that humans did not evolve, but were created in their current form, which is in the image of a divine being. They also attested that strong amounts of evidence were not available to prove that transitional human species existed. This student expatiated on this thought by saying,

> I believe that people are created on their own image, is because I believe that there's some evidence in the Quran and Sunnah for ahadith that says that Adam was created on His own image, like from clay, and then the ruH [soul] was blown into Adam. Because of that I don't believe that people evolved from apes or there was some kind of an in-between people that didn't have language, because that was another thing that the Quran talks about is having different languages, that we're created with different languages and different colors. To add to that, I would say that, from what I've viewed, the lectures that I've listened to, one of the things that I've read, it's kind of like, it is still a theory, and they don't have a lot of in between examples. With all the fossils that they've found, and things that

> they've found and dug up, there aren't, it's kind of like there's big leaps between forms that they haven't found any proof for it (Fouad, 2016, p. 114-115).

Second Order Theme 3: Students Dissociated Acceptance of Evolution from Religious Beliefs.

This second order theme is a combination of two first order themes. The researcher felt that separating these two themes compiled deeper understanding of how students separated their acceptance of evolution and their religious identity and beliefs.

First Order Theme 3a: Students Subdue Their Religious Beliefs When Learning Processes of Evolution. This first order theme was not apparent within a majority of the selected studies; however, it did emerge as an element of learning evolution students may face. One student stated, "You understand [evolution] easier, I think, because if you think about your religion while they're explaining evolution to you, you're just thinking, "No, God did that." (Troung et al., 2018, p. 111). This particular student had to actively subdue the religious teachings they identified with to fully commit to understanding evolution during their science courses. Although other students did not explicitly address this type of separation when learning about evolution, it is a concern instructors should be aware of when teaching students with varying backgrounds.

First Order Theme 3b: Students have dissociated their religious beliefs and evolution completely. This first order theme included statements from students who have completely dissociated the personal religious beliefs they hold from acceptance of evolution. These students held each component, being a religious individual and

accepting evolution, as part of their identity. However, the two components do not mix and are not used to provide evidence of each other. One student explained,

> Religion and philosophy it seems that those fields, they function to tell us why things happen, and science and physics and all the rest, they tell us how things happened. That's the difference that I get from those. Some tell us how things work and others, the philosophy and religion tell us why (Fouad, 2016, p.183).

Another student used the metaphor of looking through different windows to find different answers. They illustrated,

> There are two separate windows – science and religion … You can mix the two and they go together just fine and everything. They don't conflict generally but the stuff that you observe out of the science window isn't the same stuff that you're observing out of the religion window. You know religion is for the why and… the what's the purpose, whereas science is the what and the how it works… If you are looking at it to ask the correct questions, they [science and religion windows] might give you an answer that forms to create one big answer that complements with itself I guess, but you're not going to get the same answer out of both windows because it's two different questions (Winslow et al., 2011, p. 1039).

Within a different study, another student also used a metaphor of two different drawers to describe keeping faith and science separated. The student described,

> They are two different things that cannot be mixed, faith is something and science is something else, I don't know why people usually get confused with this topic, it

> really doesn't bother me, it is really clear in my head, I have a drawer for faith and I have drawer for evolution (Hokayem and BouJaoude, 2008, p. 405).

One student recognized that religion and evolution involved different questions; and, to answer these questions, an individual can only use information from one field of thought. An individual can use religious information to answer questions about faith, and scientific information can be used to answer questions about evolution; however, the two cannot mix. The student stated,

> Religion is not explained from an evolutionary perspective … Darwin's theory that humans came from monkeys and common descent, those, if I don't accept, I don't think religion will accept them, religion will think that human is the ultimate creature but you cannot criticize a scientific theory from a religious point of view, there's nothing common between religion and evolution, I haven't seen a Sheik or a Priest criticize evolution, you need someone who understands religion and evolution in order to criticize the theory, not someone who refuses the idea without discussion and research (Winslow et al., 2011, p.408).

Another student found that religion and evolution were separate processes because Biblical accounts could not be tested using scientific methods. This student pronounced that,

> They're (scientific and Biblical accounts) two totally different views. In the Biblical, it says that God created man and woman and everything else on earth and all this and the scientific you know it says it comes from the protocell and then we evolved into this and that and stuff like that, but it's a different aspect of

> learning, the scientific way is, I mean ‘cause you can prove that the evolutionary process and theories have occurred (McQuaide, 2006, p. 72-73).

Second Order Theme 4: Students Rely on Evidentiary Support as a Tool to Accept or Deny Evolution.

All eight studies examined in this metasynthesis demonstrated responses from students that emphasized how important having evidence was to accepting evolution. Students either accepted evolution because the evidence for evolution was convincing to that point, or students denied evolution because they perceived the evidence was not strong enough to overcome their personal religious beliefs.

Some students insisted that evidence was necessary to accept that scientific processes are happening, while also believing that there are religious explanations for scientific processes, which cannot be supported by evidence. Many comments in the first order themes of this section have both a strong insistence for evidence related to evolution and belief that religion can explain particular aspects of science without evidentiary support. Students hold their religious beliefs as the foundation of who they are and maintain their religious views without question, while at the same time insisting that one should have evidence when the topic of evolution or other scientific processes are involved. This does not imply that students cannot hold a religious belief and accept evolution.

One student, who held a strong religious belief, described that development of scientific knowledge required experiments by saying, “Because otherwise it would just be the religion of science. I don’t know how to answer that.” … “We need experiments so

that we can have concrete evidence to, in order to believe certain things, and to be able to prove it to others" (Fouad, 2016, p. 164).

First Order Theme 4a: Students Use Evidence to Support Accepting Evolution. During evolution instruction at post-secondary institutions, students emphasized the need for evidence and data to lead them to accepting evolution. Some students stated the need for evidence without giving specific examples of evidence that guided their personal acceptance of evolution. Winslow et al. (2011) quotes one student's view that having evidence is what separates science from religious faith,

> The way that they define things are different, because the Christian belief is based solely on faith. For me, there is no evidence, no hard fast evidence that I can see… Whereas science, you have hard fast evidence, something that you can put your hands on and see (p. 1039).

Other students specified what forms of evidence guided them towards the acceptance of evolution. For example, one student explained,

> I cannot say that the theory of evolution is certain but I can say that it is the best till now which has much hard evidences in its favor. And as a science student, I believe in facts and visual evidence which, were presented by the theory of evolution from the fossil studies & the clarity of prokaryotic organisms & some of our organelles (Dagher & BouJaoude, 1997, p. 435).

The following quotes were from students that provided a specific type of evidence that added to their acceptance of evolution. One student pointed to fossil records as

convincing evidence that evolution occurred. This sentiment was emphasized in the following statement,

> When [the instructor] talked about … fossils and how they found DNA from all these species that have evolved and stuff, looking back at it, that was probably a main reason that kind of convinced me to feel like this did occur. Because we have some evidence to back it up, something a few years ago, or hundreds of thousands of years ago existed. We have the stuff to prove it, I guess, in a way (Truong et al., 2018, p. 111).

Another student expressed that continental drift theory was a convincing topic when accepting evolution,

> Continental drift theory I think does … it has shown where animals have evolved, the same types of animals have evolved on the different continents and then when they split …to evolve differently in different places depending on the conditions that you know, came about and where the continents moved to …, and that's a pretty good evidence (McQuaide, 2006, p. 70).

First Order Theme 4b: Students Use Evidence as a Reason for Not Accepting Evolution. Some students were provided with evidence for evolution and continued to deny the processes within. Although most students in this section understood the evidence they were given for evolution, they felt that there should be more evidence before they were willing to accept evolution. One student stated, "Although evidences mainly from embryology, biochemistry, & paleontology are in favor of the theory of

evolution, yet I believe they are not evidence enough to the truth of such a theory" (Dagher & BouJaoude, 1997, p. 435).

Some students had misunderstandings on various forms of evidence. Dagher and BauJaoude (1997) found that most students in their study,

> made skewed judgements about which evidence is valid (direct) and which is not (historical and circumstantial). Furthermore, they seemed to want to subject the historical evidence to "tests" appropriate for direct evidence reflecting a misunderstanding of the nature of those evidences and how they relate to one another. For example, some students are not confident that historical evidence is as convincing as visualizing something in a lab during an experiment (p. 388).

Dagher and BouJaoude (2005) provided comments from students who struggled with conducting experiments about evolution in the context of time. One student stressed the difficulty of proving evolution with experimentation by highlighting the amount of time required for a change in species to occur,

> What is hard about proving evolution for instance is the fact that evolution requires long and long periods of time, thousands or even hundreds of millions of years to take place. Now this is something very hard to prove, for example they cannot wait. If you have to see evolution happening you should for example photograph an animal new and then photograph it later about a million years later, this is very hard to prove at the moment but you can depend on certain evidences for example mutation (Dagher & BouJaouode, 2005, p. 383)

Hokayem and BouJaoude (2008) also quoted several students that were not convinced of the evidence for evolution. Multiple students interviewed in Hokayem and BouJaoude (2008) gave examples of why they felt the evidence for evolution was not strong enough. Two students' quotes were provided from the collection of comments to represent the group. One student questioned fossils as evidence for evolution when stating,

> They do have laboratory experiments and they do have historical evidence but factual, I don't believe that the theories they come up with from historical evidence is factual, like a fossil is a stone, it doesn't even have cells so you can't say this is a snail, maybe it's a stone (p. 406).

Another student quoted in Hokayem and BouJaoude (2008) was not convinced of fossil evidence for the transition in humanoid species. This student surmised,

> They [scientist] haven't scanned the whole earth to see if what they're talking about is true, it's fragmented, they find one thing they make up a theory on it, they find something else, they change their theory … they're basing it on their imagination nothing else … they need to show me transitional species that are really found, not just they found a human being with a bigger jaw, it's normal for the jaw to be bigger because he used to eat other kind of food, if this is what they mean by evolution then fine but not the evolution from monkeys to human, this is another idea (p. 407).

Second order Theme 5: Exposure Time to Evolutionary Topics and Scientific Literacy Influences Students' Acceptance of Evolution.

Two first order themes emerged and are included in this section. One involved students' misunderstanding of the nature of science. One study specifically addressed students' knowledge on the nature of science, particularly their definition of a theory. The next first order theme in this section addressed how gaining deeper knowledge of evolutionary process leads students in multiple directions in their understanding process. gaining deeper information about evolution either alleviates conflict students may hold between personal religious beliefs and accepting evolution or creates a conceptual shift in understanding. Learning more about evolution in post-secondary courses may cause the student to disregard the information that is provided and invest deeper in their religious teachings. Lastly, students may feel at a standstill questions whether they should accept evolutionary topics or if they should solely rely on religious teachings as answers.

First Order Theme 5a: Students do Not Have a Strong Understanding of Nature of Science. One category of responses that Dagher & BouJaoude (2005) included in their study showed that students expected "that every step in the [scientific] method ought to be followed in the prescribed order, and following the scientific method is what gives confidence to obtained knowledge" (p. 385). This thought process was illustrated in the following student comment,

> Usually with the scientific method we start with the hypothesis and we go testing and if the hypothesis is correct it goes into being a theory but I don't know anything about evolution starting as a hypothesis and being tested, you know

> where was it tested? All we know is that he [Darwin] based it on citing he was in Galapagos Islands if I remember well and there he noticed many things. A theory {hesitant} I don't know if it is a big step or if he made any investigations concerning the thing (Dagher & BouJaoude, 2005, p. 385).

First Order Theme 5b: Deeper Understanding of Evolution Influences Students' Acceptance of Evolution. As students learn about evolutionary processes in post-secondary institutions, particularly science majors, they may perceive a conflict between what they are learning and personal religious beliefs. How new information about evolution influences a students' acceptance of evolution varies depending on the individual. The following subsections of this first order theme delineate the different student responses the researcher extracted while analyzing the selected papers.

First Order Subtheme 5b.1: Deeper Exposure to Evolution Alleviates Conflict Between Personal Religious Belief and Evolution. As students are exposed to the detailed processes that make up the components of evolution, some come to conceptual changes in their thought processes surrounding the topic. For example, one student announced, "At first I thought it was a little farfetched and then the more I learned about it, it seemed that the other idea that wasn't evolution was more farfetched than evolution itself" (McQuaide, 2006, p. 75). Troung et al. (2018) provided a narrative from a student that echoes the previous students' comment. This student stated,

> [After evolution instruction] it just made me think more, made me open my mind to see that evolution might be a possibility to me to some extent . . . at first, I just really thought that Adam and Eve and species really didn't evolve . . . but now,

> after [instruction] I was like, "Okay, maybe to some extent we did evolve" (p. 110).

Other students had been introduced to evolutionary processes earlier in their primary education; however, the depth that was provided was not substantial enough to bring about full understanding of the topic. One student described this experience by saying,

> I'd say I first learned about it in middle school or high school but I didn't understand it fully until this last year when I took it last year in college and actually saw the factual information that brought this theory about … a full understanding of it recently (McQuaide, 2006, p. 84-85).

First Order Subtheme 5b.2: Deeper Exposure to Evolution Causes the Student to Credit Their Personal Religious Teachings for the Processes They are Learning. Several students understand the deeper information they receive in a science course in a post-secondary institution about evolution, but only credit a divine being for the complexities they witness. This was illustrated by one students' explanation of the power a divine being held to link many aspects of science together,

> To think of how things change at the genetic level or the molecular genetic level, the amount of work that goes into it, makes you appreciate the fine-tuned work that Allah has in nature. It makes you appreciate how it happens together. It makes you gain an appreciation for the power of Allah, because He has power over everything (Fouad, 2016, p. 109).

Other students rely on religious teachings to provide answers to topics they have not yet found answers to through science. One student asserts,

> I think it's just my personal belief, because I know there's evolution and there's these facts, but we don't know how it actually started. We don't know what the starting point was, and that's why I choose to have my faith in religion instead of science because science may not tell me everything that has, like the beginning of people (Fouad, 2016, p. 105).

First Order Subtheme 5b.3: Deeper Exposure to Evolution Causes Students to Feel Uncomfortable About Accepting Evolution. One student honestly described their struggle with accepting evolution due to religion and simultaneously trying to achieve academically in the science class in the following statement,

> I think the reason why I don't have a very much of an opinion [about evolution] is probably didn't take a lot of that in because I was just trying to get through it. Maybe I felt like I know I don't believe this, so I'm not going to research it too much. I'm not going to pay too much attention to it. I'm going to get through this class, and take it, and get the best grade I can. So, that's probably why I don't have a very good way of explaining or giving an opinion because, I don't know, maybe I thought that it wasn't important to learn a lot about that, which now, sitting here thinking about it, it probably really is important to learn a lot about that (Fouad, 2016, p. 159).

Another student described an internal struggle between their personal religion and accepting evolution in the following statement,

> I am both religious and a believer in science. That's why I get lost and have no answer as of which view is the correct one. Sometimes I'm driven to go into its details then I get lost; I revert back to the safer side of not asking the question (Dagher & BouJaoude, 1997, p. 436).

Second Order Theme 6: Learning Environment Influences a Student's Acceptance of Evolution.

Three studies selected for analysis in this dissertation provided perspectives from students related to their physical comfort level within an evolution course and with the instructor. The first order themes included in this section collectively illustrate how student perception of personal comfort while learning about evolution. Students mentioned wanting an open atmosphere within the classroom to provide a safe environment to discuss evolution and personal religious beliefs, without feeling judgement from others. Students also appreciated being provided with examples of individuals who hold a religious belief and also accepted evolution. Lastly, some students were able to participate in a deeper conversation about evolution when they felt that their instructor would not attempt to sway their decision to accept evolution one way or another.

First Order Theme 6a: Students Fear Being Judged for Their Personal Views.

Student reach their level of acceptance of evolution in different ways. A student's level of acceptance of evolution can also change through their post-secondary experiences and after they have left a post-secondary institution. Because of this, students' comfort level in joining classroom discussions may vary. One student highlights the appreciation they

had for the instructor for allowing various methods of discussion to take place surrounding the topic of evolution. This student reported,

> It made me feel safe … I felt safer … It helped me feel that we could be open and say what we actually thought about evolution without having to go into class and voice it out in front of [a bunch of] people verbally, [we could also choose to] reply to the teacher one-on-one (Troung et al., 2018, p. 110).

First Order Theme 6b: Religious Role Models, That Pursue Science, Influence Students' Acceptance of Evolution. In some cases, instructors of evolution courses provided students with examples of scientists who fully accepted evolution, and held personal religious beliefs. Both students who held personal religious beliefs and those who did not appreciated the inclusion of these individuals. Two non-religious students questioned the stereotypes they held toward religious scientists after being introduced to individuals who conducted strong scientific research and maintained their personal religious beliefs. One student commented, "I appreciated that there are people who believe in evolution who are religiously affiliated because it showed me that they did not let their religion interfere with fact" (Barnes et al., 2017a, p. 109). The second student resonated this sentiment when they said, "I appreciated that scientists are able to be considered religions without it compromising their research" (Barnes et al., 2017a, p. 109).

Other students changed their position on their perceived conflict between religion and evolution when they learned more about scientists who held religious beliefs. One student commented,

> I think [my perceived conflict changed] when the instructor was talking about that there have been scientists who have studied evolution and been involved with evolution that still believe in religion. It was just like they were able to go through it and still have their relationship and faith in God, but learn and understand evolution (Troung et al., 2018, p. 112-113).

Another student credits their Christian professor as being the role model that led them to accepting evolution. This student claims,

> I think that if I had gone to a public university and had the same teachings, I don't know if I would have been open to accepting it [evolution]. Maybe I would have just done the same thing I did in high school when I had to write that paper – just kind of ignore it (Winslow et al., 2011, p. 1043).

First Order Theme 6c: Students' Comfort with Their Instructor Influences Acceptance of Evolution. Troung et al. (2018) concluded that "the majority of students said that the instructor allowed for them to form their own opinions about evolution, and they felt as though the instructor was not forcing them to accept evolution" (p. 111). One student illustrated their experience by saying, "Some people take their religion really seriously. For someone to say, "Don't believe in that, believe in this," it's just not right. The instructor didn't do that. She said that she respects everyone's beliefs" (Troung et al., 2018, p. 111)

Phase III: Connections to Current Research

During this final phase of the meta-synthesis process the second order themes that were extracted from the eight selected studies were used as a heuristic to compare how

students' perspectives of accepting and understanding evolution in these studies to present studies on the topic. Direct quotes from post-secondary students were included during the previous phase of constructing first and second order themes. Student perceptions regarding personal acceptance and understanding of evolution offered parallel conclusions to those drawn from previous studies as well as discrepancies. In the next section, comparisons between the patterns that emerged through the meta-synthesis with current research is reported for each second order theme extracted.

Second Order Theme 1: Students Perceive a Conflict Between Religion and Evolution.

Based on students' perspectives reported in the eight selected studies, students found accepting evolution difficult during their post-secondary courses due to concerns that tenets of the evolutionary process would conflict with their personal religious beliefs. This perceived conflict was illustrated in the following first order themes: (a) students rely firmly on their religious beliefs as an explanation to any change in a species; (b) students' acceptance of evolution is influenced by negative stereotypes they hold of scientific figures; (c) students avoid the topic of evolution due to fear that acceptance will conflict or challenge their personal religious beliefs; (d) students do not accept evolution due to influences by family. The influence of a students' religious beliefs on their acceptance and understanding of evolution has been described in several previous studies. Downie and Barron (2000) concluded that the principal reason first year students in a Scottish university biology courses selected for rejecting evolution was due to "acceptance of the literal truth of a religious creation account" (p. 144). Lawson (1992)

concluded that high school students who were “highly religious students are more likely to express a belief in special creation and are less likely to give it up during [science] instruction” (p. 165).

This meta-synthesis revealed that some students avoid or do not accept evolution due to their cultural and religious beliefs. Students’ commented that not accepting evolution was also due to influences by family members and negative stereotypes towards scientists. Nadelson and Hardy (2015) examined the deeper relationship between students’ trust in science and scientists and acceptance of evolution. After conducting an online survey with 195 students, who at the time were enrolled in a large university, Nadelson and Hardy (2015) found “trust in science and scientists was associated with overall evolution acceptance and that trust in science explained a significant proportion of variance in overall evolution acceptance” (p. 4). Nadelson and Hardy (2015) also found that trust in scientists, political orientation of the student, and religiosity of the student overlapped with the students’ acceptance of evolution. No comments related to political orientation were found in this meta-synthesis study and this may be something to explore in the future.

Based on students’ views from this meta-synthesis, students’ acceptance of evolution was also influenced by their families’ views. Many aspects of a students’ experiences (including learning from family) can influence a students’ acceptance of evolution (Borgerding et al., 2017). Various studies have addressed what may influence a students’ acceptance of evolution; however, a study strictly looking at family influences

on post-secondary students was not found at the time of this study. This influence may be something to explore further in the future.

Second Order Theme 2: Students Find a Compromise Between Evolution and Their Religious Beliefs.

Students' perspectives within this meta-synthesis revealed an aspect of accepting and understanding evolution which the researcher defines as theistic evolution. The first order themes included in this section were: (a) students accepted theistic evolution and (b) students accepted the idea that all species have evolved, except for humans. Yasri & Mancy (2014) categorize this particular view in two ways, after interviewing students from a Christian high school in Thailand,

> In the first, science and religion are perceived to provide the same knowledge (called coalescence): science is the method used by God, science itself points to God. In the second, science and religion are acknowledged to provide different kinds of knowledge; however, they interact with each other in a positive way (called complement): science fills missing gaps in religion; religion helps science justify its appropriateness (Yasri & Mancy, 2014, p. 31-32).

Although this meta-synthesis analyzed only studies focused on post-secondary students, students' comments paralleled with Yasri and Mancy's (2014) findings derived from high school student interviews.

Second Order Theme 3: Students Dissociate Acceptance of Evolution from Religious Beliefs.

Within this second order theme, students perceive science and religion to be exclusive of one another with each component pertaining to different questions. Two first order themes were included in this section, (a) students subdue their religious beliefs when learning processes of evolution and (b) students have dissociated their religious beliefs and evolution completely. These patterns were also observed in previous studies (Borgerding et al., 2017; Chinsamy & Plaganyi, 2008; Yasri & Mancy, 2014). Yasri & Mancy (2014) categorized students' comments consistent with the findings of this meta-synthesis. Yasri and Mancy (2014) describe,

> science and religion are two non-overlapping domains that generate knowledge to answer different kinds of questions (science asks 'how', whereas religion asks 'why' questions), or do so using different methods (science deals with physical and empirical data, whereas religion concerns ultimate meaning and moral value). As a result, there can be no conflict between the two (p. 26).

Second Order Theme 4: Students Rely on Evidentiary Support as a Tool to Accept or Deny Evolution.

This second order theme includes comments from students that claim the presence of evidence for evolution as either a reason for their acceptance or denial of evolution. The two first order themes within this group are, (a) students emphasize the necessity of evidence to support accepting evolution and (b) students emphasize lack of evidence as a reason for not accepting evolution. Student participants in Abraham et al. (2012) used

evidence, specifically stasis in lineages and fossils, as guidance in accepting evolution while other students found flaws in the evolutionary theory. Student perceptions revealed in this meta-synthesis mirror the same uses for evidence, as either proof of accepting evolution or revealing flaws in evolution.

Clores and Limjap (2006) also witnessed how college freshman students in a Catholic university in the Philippines used evidence to guide their acceptance of evolution. Most students in the study accepted evolution because they felt it was supported by numerous amounts of evidence (Clores & Limjap, 2006). These students were also convinced that scientists will find more evidence and much evidence has not yet been found (Clores & Limjap, 2006). Other students were not convinced that there was enough evidence to support evolution, particularly when related to human evolution (Clores & Limjap, 2006).

Sinatra et al. (2003) suggested that "conceptual change is more likely to occur when students can experience the phenomena directly. In class, experiments using fruit flies or cross-fertilization of plants capitalize on children's natural curiosity and allow opportunities for observations that are compelling" (p. 194).

Second Order Theme 5: Exposure Time to Evolutionary Topics and Scientific Literacy Influences Students' Accepting Evolution.

Comments from students within this meta-synthesis revealed that increased exposure to evolutionary processes or deeper discussions about the topic resulted in three different reactions from students: (a) deeper exposure of evolution alleviated conflicts students had between personal religious belief and accepting evolution; (b) deeper

exposure to evolution caused the student to credit their personal religious teachings for the processes they are learning; and (c) deeper exposure to evolution causes students to feel uncomfortable about accepting evolution. A second first order theme included in this section was related to students' weakness in understanding the nature of science, which influenced students' acceptance of evolution.

As Sinatra et al. (2003) posited,

> Understanding the sources of conflict and resistance to evolution and the challenges of fostering change on this topic is a next step to developing successful approaches to evolution instruction. Students come with entrenched ideas and ways of viewing the world that are in conflict with scientific perspectives such as species change, deep time, and difficult-to observe phenomena, such as genetic drift. Conceptual change research suggests that educators must be aware of students' preconceived ideas that they bring to the classroom, and must design instruction to give students the opportunity to think deeply about alternative perspectives (p. 194).

Akyol et al. (2012) found that "pre-service teachers' views on nature of science were directly linked to their understanding and acceptance of evolution and their self-efficacy for teaching evolution" (p. 947) and understanding of "nature of science was directly associated with lower sense of self-efficacy beliefs regarding teaching evolution" (p. 950).

Second Order Theme 6: Learning Environment Influences a Student's Acceptance of Evolution.

Several students' comments proved insightful on the relationship between accepting and understanding evolution and the environment that the topics are being discussed. Three first order themes further illustrate this point: (a) students want to feel comfortable learning about evolution, without fear of being judged for their personal views, (b) students accept evolution more in the presence of religious role models that also accept evolution, and (c) students' comfort level with their instructor influences acceptance of evolution.

There are a variety of methods instructors can introduce to discuss evolution in classrooms where students' acceptance levels of evolution may vary. "A preliminary survey of science majors enrolled in an introductory biology lecture course indicates that students can be exposed to the concepts of evolutionary theory in a non-confrontational manner that promotes their willingness to study this important area of biology" (Findley et al., 2001, p. 12). Southerland and Scharmann (2013) noted,

> that it is valuable for teachers to describe that science does not assert that there are no supernatural forces, and it does not refute the existence of God. Instead, science refuses to invoke supernatural or metaphysical explanations in constructing knowledge—as scientific explanations must rely on logic, observable evidence, patterns that can be independently inferred from observable data, and testing. That science does not use the supernatural in its work does not suggest

> that the supernatural does not exist—just that the use of the supernatural in constructing an explanation makes that explanation nonscientific (p. 62-63).

How evolution is presented in the classroom has been addressed in previous studies; however, based on the comments provided by students in the eight selected studies for this meta-synthesis, deeper exploration into the comfort level of the student while in an evolution class may be considered for further research. Particularly inviting role models that can connect to students' views and acceptance of evolution may be considered for future investigation.

Chapter Summary

This chapter presented findings from the three phases of the meta-synthesis process described in Chapter III. A descriptive synopsis of each of the eight studies selected for analysis in this dissertation was provided in Phase I of the meta-synthesis process. The first and second order themes that emerged from the metasyntheis of the eight original studies were reported in Phase II. These second order themes included: perceived conflict between religion and evolution, views of evolution strengthen religious beliefs, religious beliefs and acceptance of evolution are kept separate from each other, evidentiary support is used to accept or deny evolution, exposure to evolution and scientific literacy influence acceptance of evolution, and the environment in which students learn evolution can influence their acceptance of evolution. Lastly, Phase III involved comparing the findings of the second order themes supported by student comments from the eight selected studies to the current research literature related to postsecondary students' acceptance and understanding of evolution.

CHAPTER V

Conclusions, Implications, and Recommendations

Overview of the Study

Many current social and global issues today involve understanding of sciences particularly the overarching link to all sciences, evolution. Issues such as climate change, gene editing, and global food production are but a few concerns for which knowledge of evolution provides a foundation. Currently, a large proportion of United States residents does not accept the tenets of evolution. According to a 2013 Harris poll, only 47% of polled individuals accepted evolution. The various environmental and biological decisions our students as democratic citizens will make in the future emphasizes the urgency for further examination of how students understand evolution.

Understanding what factors influence an individual's acceptance of evolution is a complex field of study. In this meta-synthesis study, the researcher specifically analyzed and explored post-secondary students' perceptions towards acceptance and understanding of evolution. The data source for this meta-synthesis study were current studies identified using inclusion and exclusion criteria. Three phases were constructed using the student responses from the original eight studies. Phase 1 included a descriptive synopsis of the eight original studies. During Phase II, first and second order themes were

interpreted from the original studies within the boundaries set by the original research questions. The research questions were:

1. What perceived conflicts do post-secondary students face when learning about evolution?
2. Based on post-secondary students' perspectives, how do personal religious beliefs influence understanding and accepting evolution?

These research questions provided the framework through which the findings were interpreted. After focusing on students' perceptions related to acceptance and understanding of evolution, the researcher found several first order themes, or patterns from the student comments in the selected studies. These first order themes were condensed into second order themes. The second order themes included: perceived conflict between religion and evolution, views of evolution strengthen religious beliefs, religious beliefs and acceptance of evolution are kept separate from each other, evidentiary support is used to accept or deny evolution, exposure to evolution and scientific literacy influence acceptance of evolution, and the environment in which students learn evolution can influence their acceptance of evolution.

Lastly during Phase III, the second order themes that were highlighted from the students' perceptions of accepting and understanding evolution were compared to the current relevant literature. Similarities and discrepancies were discussed between the student comments and the current literature.

Conclusions

Current studies have explored students' perceptions toward acceptance and understanding of evolution. However, each completed study is a fragment of the overall picture concerning the influences students face when learning about evolution. Previous research examined the influence of non-academic factors, such as personal religious beliefs and cultural influences on accepting and understanding evolution. Other studies focused on academic factors, such as low exposure to evolution or misconceptions about the topic. Several studies also utilized quantitative methods to survey students' views on evolution and interpret what the students may be experiencing based on survey data.

Although there exist qualitative studies that explore students' perceptions toward accepting and understanding evolution, at the time of this study, no meta-synthesis studies that specifically focused on post-secondary students' perceptions toward acceptance and understanding of evolution were found. In general, there were also very few strictly qualitative studies which examined factors related to post-secondary students' perceptions towards acceptance and understanding of evolution.

Due to this gap in the literature pertaining to post-secondary students' perceptions toward acceptance and understanding of evolution, and the emphasis of evolution as the overarching theme for all sciences, this study sought to gain deeper knowledge on the topic. Specifically, in this study, the researcher synthesized qualitative research allowing for knowledge gained from previous individual studies to come together in a broader, in-depth, and more holistic examination of post-secondary students' perceptions towards acceptance and understanding of evolution.

Also, of the eight original studies analyzed in this meta-synthesis, none contained all the themes or patterns that were extracted during this study. Therefore, conducting a meta-synthesis provided a larger and more complete picture of post-secondary students' perceptions towards acceptance and understanding of evolution.

This larger picture shows how students' acceptance and understanding of evolution are based on their personal religious views: either they perceive a conflict between evolution and their religious beliefs; they hold a theistic evolution view; they hold a religious belief and acceptance of evolution but do not combine the two; or they want to feel comfortable learning about evolution without being judged, if they hold a religious belief. Using the actual quotes from students throughout the reporting of the findings of this meta-synthesis offered insight into the personal views straight from the students, not from researchers' interpretations.

Experience an instructor within a post-secondary institution has made the researcher aware of the value of the use of student feedback to enhance the quality of teaching and the learning experience for the student. Due to the historically controversial stance surrounding evolution, specifically related to perceived conflicts between personal religious beliefs and accepting evolution, students may not feel comfortable expressing perceived conflicts they have when learning about evolution in science courses. Students may also experience confusion or feel they are betraying their religious beliefs if continued exposure to evolution strengthens their acceptance of the processes.

Based on the studies selected for this meta-synthesis, more students than not accepted all or some parts of the evolutionary process, no matter if they held religious

beliefs as well. Most of the controversy over accepting evolution related to human evolution and/or macroevolution. As a science educator, this is encouraging. Several aspects of evolutionary processes can be explained using many different diverse organisms, and do not have to reference human evolution. This does not mean that human evolution should be ignored; however, during the introduction of various evolutionary processes, examples can be used from many organisms, not just humans.

Comments in second-order theme 1 in which students perceived a conflict between personal religious beliefs and accepting evolution, were centralized around the origin of living organisms. Evolutionary processes do not describe the origin of life, but provide answers for how organisms change over time, specifically changes in allele frequencies within a population. It should be made clear to students, when teaching about evolution, that origin of life is not the subject of evolution. The topic of evolution makes no claims on the origin of life, but seeks to answer questions related to changes in a species population over time.

The historical controversy around evolution was presented in Chapter II of this study as it related to inclusion of evolution in textbooks and the removal or discrediting of evolution in the classroom via judicial cases. The continued push for the removal of evolution from the classroom is supported mostly by individuals who are biblical literalists. The drive for removal of evolution from the classroom continues into the present day. Anti-evolution bills continue to be introduced in 2019 in several states.

Biblical literalists believe that all organisms were created by a divine being, in their current form, and that evolution had no part in the diversity we see today. Based on

the studies selected for this meta-synthesis, very few students identified as biblical literalists. Most students were placed into two categories by the researcher based on their comments. One category included students that held religious beliefs and felt that both evolution and their religious beliefs worked together to answer various questions about life. These comments were described within Second-order theme 2.

In Second-order theme 3, student comments demonstrated they also held religious beliefs but did not combine their religious beliefs and evolution to answer the same questions. Questions over topics such as a divine being or the presence of a soul were answered using religion, while scientific questions, that could be tested, were answered using a scientific context like evolution. In addition to the similarity that both of these groups of students held religious beliefs, both groups also accepted evolution. The comments highlighted in this study presented a spectrum of how students combine their religious beliefs with acceptance of evolution.

Reflecting on prior studies related to acceptance of evolution by students, the findings of this study do not totally agree or disagree with findings from previous studies. For example, some past studies have concluded that a negative relationship exists between an individual's religious beliefs and accepting evolution; however, researchers have also found that there is little or no relationship between an individual's religious beliefs and understanding evolution (Berkman & Plutzer, 2011; Bishop & Anderson, 1990; Demastes et al., 1995; Hermann, 2008; Pobiner, 2016). This meta-synthesis study demonstrated evidence supporting differing conclusions presented during the literature review in Chapter II.

Based on the findings of this meta-synthesis, the researcher posits that student perceptions fall on a spectrum regarding the relationship between personal religious beliefs and acceptance of evolution. Some students in this study did not accept evolution because of their religious beliefs, while some students had no problem accepting and understanding evolution and maintaining religious convictions. It is inaccurate to say that having a religious belief will lead a student to never accepting and understanding evolution. The interaction of a students' religious beliefs with their evolutionary understanding is very different for each person.

Another component of the findings from this metasynthesis that not was not obvious in the current literature was the potential benefit of guest speakers from scientific fields talking to science classes. Various speakers can be invited that hold differing religious beliefs and provide students with examples of individuals who contribute to scientific fields while maintaining personal beliefs. This can be a tool teachers use to show students that learning about evolution and participating in science do not have to conflict or hinder personal religious or cultural beliefs. The findings of this study highlight the importance of invitation of various scientific role models to a class as a positive measure for students who are figuring out the relationship between their personal religious beliefs and accepting evolution.

Related to inviting scientific role models to speak in science classes is the role instructors have on students' comfort in learning about evolution. This study did highlight comments in which students felt at ease learning about evolution because the instructor provided a non-judgmental environment for the students. Past research is

addressed in Chapter II of this study which introduced the effects teachers have on students' progress of learning evolution. Studies have shown that teachers feel underprepared to teach evolution, they hold misconceptions that are then passed to the students, or they avoid the topic of evolution because of conflict with their personal beliefs or due to conflict with parents and administration (Aguillard, 1999; Borgerding et al., 2015; Brem et al., 2003; Nehm et al., 2009; Shankar, 1989). It is important for teachers to be trained, not only in the correct content of biological evolution, but also how to initiate the topic of evolution to classrooms of students that may hold different religious beliefs. Avoidance of evolution in a science classroom should not be the norm for any teacher, no matter what educational level they are teaching.

There are still many discussions to be held related to the relationship between students' religious beliefs and their pathway to accepting and understanding evolution. Hopefully, this meta-synthesis study will add to the conversation and show that there is no one way that students integrate learning evolution with the cultural and religious beliefs they hold. Instead, their perceptions lie across a spectrum regarding the relationship between religion and evolution understanding, which varies for each student and may change during the educational career of the student. It is essential that post-secondary faculty, as well as primary and secondary instructors, understand this and ensure that students feel comfortable learning about evolution, no matter what their religious or cultural beliefs are.

Implications for Practice

Evolution in the scientific community is a central unifying theme between all sciences, and teaching science courses without evolution is akin to presenting facts without context. The voting population face many wide scale decisions involving topics in which evolution provides basic understanding of the topic. These topics include climate change, food production, disease resistance and spread, genetic modification, and others. These issues will continue to be discussed for many years. Students moving through our education system should have a strong understanding of evolutionary processes. This should include being introduced to the topic of evolution early in the educational career, and maintaining instruction as an underlying theme throughout the students' primary and secondary school career. An early introduction to evolution can eliminate many misconceptions and discomfort students may feel when learning evolution in a post-secondary institution.

The current literature provides many factors related to students' perceptions towards acceptance and understanding of evolution. The eight selected studies in this metasynthesis also dealt with students at different levels in their educational careers, with different life experiences, and various cultural and religious beliefs. As instructors, every student we encounter is different and each student approaches learning evolution differently. It should be expected that students will be at distinctive starting points pertaining to their level of acceptance and understanding of evolution; instructors will need to meet students where they are in their experience of learning evolution.

Thus, it is important that instructors develop relationships with students and insure that no matter where a students' views on evolution are rooted, the student feels comfortable, and the student is not judged or made to feel as if their personal beliefs are at odds with the instructors' views. This study also elaborates the various positions that students can hold between their personal religious beliefs and accepting and understanding evolution. The more the instructor can understand about the conflict students may exhibit between accepting and understanding evolution and personal religious beliefs, the better guidance the instructor can provide to the student as they teach about the various evolutionary processes.

Science instructors will come into contact with many different students that hold various religious beliefs and it is imperative that instructors discuss evolution in a way that makes students feel comfortable. Students who feel as if their personal religious beliefs are being judged will shy away from learning, and they may also maintain a conflict between religion and evolution.

The studies analyzed in this meta-synthesis show that students' thoughts' about their relationship between personal religious beliefs and acceptance of evolution fall on a spectrum. This spectrum includes students that perceive a conflict between religious beliefs and evolution, students that use religious beliefs and evolution together to answer questions, and students that maintain a separation between their religious beliefs and their acceptance of evolution. Regardless of their religious beliefs, students want to feel comfortable when learning about evolution.

Recommendations for Practice

Based on the findings of this meta-synthesis, the researcher recommends that resources be provided to all science instructors, at all education levels, allowing instructors to construct the best environment to discuss evolution and evolutionary processes. Any perceived conflict students may experience between religious beliefs and evolution should not be dismissed, but discussed in a safe and non-judgmental manner. This also means that instructors should feel comfortable addressing misconceptions and negative feelings that students may bring into the classroom.

Resources for instructors should include methods for introducing the topic of evolution and how to maintain the topic of evolution as an underlying theme throughout various science topics. This would involve training at the pre-service teacher level, potential meetings with mentor teachers, opportunities to take additional classes related to the teaching of evolution, and providing teachers with age appropriate class activities that engage students in evolutionary processes. At the individual student level, instructors should be given resources on how to invite students to have one-on-one discussions with the instructor if they perceive conflict between their beliefs and evolutionary topics.

Administrators could also engage with some of the same resources provided to teachers so they have the ability to also talk one-on-one with students or parents that may perceive conflict between personal beliefs and evolution. It is in the hands of educators to ensure students are provided with clear information related to biological evolution and that conflict between evolution and personal cultural and religious beliefs do not persist. Students should be introduced to information that makes them aware that there are many

ways an individual can accept evolution while maintaining their personal beliefs. This will ultimately result in individuals who are provided with the knowledge that can inform major decisions they may make in the future.

Recommendations for Future Research

In this meta-synthesis study, the researcher highlighted the relationship spectrum that students hold between their personal religious beliefs and acceptance and understanding of evolution. Continued research should occur to record how the spectrum may shift and to discover new trends when they appear. Continued qualitative research should be conducted specifically with the post-secondary population to ensure that students have the foundational knowledge about evolution that can help add to the conversation of issues facing our society. Studies related to students' perceived conflicts between personal beliefs and evolution should be conducted at various post-secondary institutions in different regions of the United States and globally. Continued research should also be expanded between post-secondary institutions that introduce the topic of evolution early in the career of a science major versus later in the students' course work.

During the search of current literature, it was also noted that many of the current studies related to students' acceptance and understanding of evolution were quantitative or mixed method in nature. Due to the nature of these studies, an attempt at a meta-analysis or other methods used for synthesizing qualitative and quantitative studies may also be a direction for future research.

Besides adding to the information about students' perceived conflict between personal beliefs and accepting and understanding evolution, emphasis needs to be made

on how instructors at all levels are encouraging the inclusion and understanding of evolution throughout science courses. It would be informative to know what instruction and support related to evolution is provided to students at all levels, and what similarities and differences there are between various regions of the country. After exploring the finding of this study, research to better understand how pre-service teachers are taught to address students with various religious beliefs in a science classroom is needed. Witnessing the range students display when discussing their perceived conflict with personal religious beliefs and acceptance of evolution suggests that there will not be a "one size fits all" method for evolution instruction. Research about evolution instruction should be conducted to quantify what methods are most valuable and for which students.

Conducting exploratory studies with college professors and instructors at post-secondary institutions would add to understanding teaching methods for evolution related to students' acceptance and understanding of the topic. This study did not examine instructors' personal religious beliefs and if instructor beliefs influence the students' understanding and acceptance of evolution. Exploring the worldview instructors bring to the classroom could add to the conversation surrounding teaching evolution.

Examining particular instruction methods related to students' acceptance and understanding of evolution is imperative in understanding the way in which students connect and feel comfortable learning about evolution, particularly if they perceive a conflict between evolution and personal beliefs. Any of these implications for future research could prove advantageous for further understanding of the perceptions post-secondary students hold when learning about evolution.

Final Reflections

Due to the nature of meta-synthesis studies, the findings presented in this study are not original. However, the amount of variation within students' perceived conflict between personal religious beliefs and accepting evolution would not have been apparent without the ability to bring multiple views together in one metasynthesis study. There is no denying the importance of evolution as a foundational context for all sciences. For this reason, breaking down the continued controversy surrounding evolution is so important. Without the push to demand for strong scientific education for our students, misconceptions will be allowed to flourish and major scientific issues in our society will be ignored, with significant detriment to all citizens.

REFERENCES

Abraham, J.K., Perez, K., Downey, N., Herron, J., & Meir, E. (2012). Short lesion plan associated with increased acceptance of evolutionary theory and potential change in three alternate conceptions of macroevolution in undergraduate students. *CBE-Life Sciences Education, 11*(2), 152-164.

Aguillard, D. (1999). Evolution education in Louisiana public schools: a decade following: Edwards v Aguillard. *The American Biology Teacher, 61*(3) 182-188.

Aguirre, R. T., & Bolton, K. W. (2014). Qualitative interpretive meta-synthesis in social work research: Uncharted territory. *Journal of Social Work, 14*(3), 279-294.

Akyol, G., Tekkaya, C. Sungur, S., & Traynor, A. (2012). Modeling the interrelationships among pre-service science teachers' understanding and acceptance of evolution, their views on nature of science and self-efficacy beliefs regarding teaching evolution. *Journal of Science Teacher Education, 23*(8), 937-957.

Alters, B. J., & Nelson, C. E. (2002). Perspective: Teaching evolution in higher education. *Evolution, 56*(10), 1891-1901.

American Association for the Advancement of Science. (1990). *Science for all Americans.* New York, NY: Oxford University Press.

American Association for the Advancement of Science. (1993). *Benchmarks for science literacy.* New York, NY: Oxford University Press.

Barnes, M. E., & Brownell, S. E. (2018). Experiences and practices of evolution instructors at Christian universities that can inform culturally competent evolution education. *Science Education, 102*(1), 36-59.

Barnes, M. E., Elser, J., & Brownell, S. E. (2017a). Impact of a Short Evolution Module on Students' Perceived Conflict between Religion and Evolution. *The American Biology Teacher, 79*(2), 104-111.

Barnes, M. E., Evans, E. M., Hazel, A., Brownell, S. E., & Nesse, R. M. (2017b). Teleological reasoning, not acceptance of evolution, impacts students' ability to learn natural selection. *Evolution: Education and Outreach, 10*(1), 1-12.

Beckwith, F. J. (2003). Science and religion twenty years after McLean vs. Arkansas: Evolution, public education and the new challenge of intelligent design. *Harvard Journal of Law and Public Policy, 26*(2), 455–499.

Berkman, M. B., & Plutzer, E. (2011). Defeating creationism in the courtroom, but not in the classroom. *Science, 331*(6016), 404-405.

Berkman, M. B., & Plutzer, E. (2011). Local autonomy versus state constraints: Balancing evolution and creationism in US high schools. *Publius: The Journal of Federalism*, *41*(4), 610-635.

Bishop, B. A., & Anderson, C. W. (1990). Student conceptions of natural selection and its role in evolution. *Journal of research in science teaching*, *27*(5), 415-427.

Blackwell, W. H., Powell, M. J., & Dukes G. H. (2003). The problem of student acceptance of evolution. *Journal of Biological Education*, *37*(2), 58-67.

Bondas, T., & Hall, E. O. (2007). Challenges in approaching metasynthesis research. *Qualitative Health Research, 17*(1), 113-121.

Borgerding, L. A., Klein, V. A., Ghosh, R., & Eibel, A. (2015). Student teachers' approaches to teaching biological evolution. *Journal of Science Teacher Education, 26*(4), 371-392.

Borgerding, L. A., Deniz, H., & Anderson, E. S. (2017). Evolution acceptance and epistemological beliefs of college biology students. *Journal of Research in Science Teaching, 54*(4), 493-519.

Boyd, D., Lankford, H., Loeb, S., & Wyckoff, J. (2005). The draw of home: How teachers' preferences for proximity disadvantage urban schools. *Journal of Policy Analysis and Management, 24*(1), 113-132.

Brem, S. K., Ranney, M., & Schindel, J. (2003). Perceived consequences of evolution: College students perceive negative personal and social impact in evolutionary theory. *Science Education, 87*(2), 181-206.

Brickhouse, N. W., Dagher, Z. R., Letts, I. V., William, J., & Shipman, H. L. (2000). Diversity of students' views about evidence, theory, and the interface between science and religion in an astronomy course. *Journal of Research in Science Teaching, 37*(4), 340-362.

Brown, J. (2015). *Measuring the acceptance of evolutionary theory: A profile of science majors in Texas 2-year colleges* (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (UMI No. 3724656).

Campbell, N. A., Reece, J. B., & Mitchell, L. G. (1999). *Biology* (5th ed.) Menlo Park,

CA: Benjamin/Cummings Publishing Co.

Carr, J. P. (2017). Evolution Education and State Politics. *BioScience, 67*(8), 687-687.

Chinsamy A., & Plaganyi, E. (2008). Accepting evolution. *Outlook on Evolution and Society, 62*(1), 248-254).

Clores, M. A., & Limjap, A. A. (2006). Diversity of students' beliefs about biological evolution. Asia Pacific Journal of Education, *26*(1), 65-77.

Cobern. W.W. (1991). *Worldview theory and science education research, NARST monograph no. 3*. Manhattan, KS: National Association for Research in Science Teaching. Retrieved June 13, 2018 from http://www.wmich.edu/slcsp/SLCSP088.pdf

Cobern, W. W. (2000). The nature of science and the role of knowledge and belief. *Science & Education, 9*(3), 219-246.

Cavallo A.M., & McCall, D. (2008). Seeing may not mean believing: examining students' understanding & beliefs in evolution. *The American Biology Teacher, 70*(9), 522-530.

Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). Los Angeles, CA: Sage.

Creswell, J. W., & Miller, D. L. (2000). Determining validity in qualitative inquiry. *Theory into practice, 39*(3), 124-130.

Cunningham D.L., & Wescott D.J. (2009). Still more "fancy" and "myth" than "fact" in students' conceptions of evolution. *Evolution Education Outreach, 2*(3), 505-517.

Dagher, Z. R., & BouJaoude, S. (1997). Scientific views and religious beliefs of college

students: The case of biological evolution. *Journal of Research in Science Teaching*, *34*(5), 429-445.

Dagher, Z. R., & BouJaoude, S. (2005). Students' perceptions of the nature of evolutionary theory. *Science Education*, *89*(3), 378-391.

Deboer, G.E. (2000). Scientific literacy: another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching, 37*(6), 582-601.

Demastes, S. S., Settlage, J., & Good, R. (1995). Students' conceptions of natural selection and its role in evolution: Cases of replication and comparison. *Journal of Research in Science Teaching*, *32*(5), 535-550.

DiGiuseppe, M. (2014). Representing Nature of Science in a Science Textbook: Exploring author–editor–publisher interactions. *International Journal of Science Education*, *36*(7), 1061-1082.

Dixon-Woods, M., Agarwal, S., Jones, D., Young, B., & Sutton, A. (2005). Synthesizing qualitative and quantitative evidence: a review of possible methods. *Journal of Health Services Research & Policy*, *10*(1), 45-53.

Dixon-Woods, M., Bonas,, S., Booth, A., Jones, D. R., Miller, T., Sutton, A. J., Shaw, R. L., Smith, J. A., & Young, B. (2006). ‘How can systematic reviews incorporate qualitative research? A critical perspective’. *Qualitative Research* 6(1), 27-44.

Downie, J. R., & Barron, N. J. (2000). Evolution and religion: attitudes of Scottish first year biology and medical students to the teaching of evolutionary biology. *Journal of Biological Education*, *34*(3), 139-146.

Eakin, J. M., & Mykhalovskiy, E. (2003). Reframing the evaluation of qualitative health research: reflections on a review of appraisal guidelines in the health sciences. *Journal of Evaluation in Clinical Practice*, *9*(2), 187-194.

Evans, S. (2003). Evolution: Still deep in the heart of textbooks. *Reports of the National Center for Science Education*, *23*(5), 5-6.

Findley, A. M., Lindsey, S. J., & Watts, S. (2001). *The Impact of Religious Belief on Learning in the Science Classroom.* Paper presentation at the meeting of the Annual Meeting of the Mid-South Educational Research Association, Little Rock, AR.

Finfgeld, D. L. (2003). Meta-synthesis: The state of the art so far. *Qualitative health research*, *13*(7), 893-904.

Finlayson, K., & Dixon, A. (2008). Qualitative meta-synthesis: a guide for the novice. *Nurse Researcher*, *15*(2), 59-71.

Forrest, B. (2018). *Why academic freedom is a fraud: The threat to science education.* Darwin Day at SFA guest speaker, Nacogdoches, TX.

Fouad, K. E. (2016). American Muslim undergraduates' views on evolution (doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (UMI No. 10110222).

Friedrichsen, P. J., Linke, N., & Barnett, E. (2016). Biology teachers' professional development needs for teaching evolution. *Science Educator*, *25*(1), 51-61.

Glaze, A. L. (2017). Divided we fall: The evolution controversy as a driver for rethinking

science education, Conference Proceedings of the American Education Research Association, San Antonio, TX. ResearchGate.

Glaze, A. L., & Goldston, M. J. (2015). Evolution and science teaching and learning in the United States: A critical review of literature 2000-2013. *Science Education*, *99*(3), 500-518.

Glaze, A., Goldston, M., & Dantzler, J. (2015). Evolution in the Southeastern USA: Factors influencing acceptance and rejection in pre-service science teachers. *International Journal of Science & Mathematics Education*, *13*(6), 1189-1209.

Gould, S. J. (1981). Evolution as fact and theory. *Discover*, *2*(5), 34-37.

Grabiner, J. V., & Miller, P. D. (1974). Effects of the Scopes trial. *Science*, *185*(4154), 832-837.

Greenbank, P. (2003). The role of values in educational research: The case for reflexivity. *British educational research journal*, *29*(6), 791-801.

Griffith, J. A., & Brem, S. K. (2004). Teaching evolutionary biology: Pressures, stress, and coping. *Journal of Research in Science Teaching*, *41*(8), 791-809.

Guba, E. G. (1981). Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Communication and Technology Journal*, *29*(2), 75-91.

Heddy, B. C., & Nadelson, L. S. (2013). The variables related to public acceptance of evolution in the United States. *Evolution: Education and Outreach*, *6*(3), 2-14.

Hermann, R.S. (2008). Evolution as a controversial issue: a review of instructional approaches. *Science & Education, 17,* 1011-1032.

Hermann, R. S. (2012). Cognitive apartheid: on the manner in which high school students

understand evolution without believing in evolution. *Evolution: Education and Outreach*, *5*(4), 619-628.

Hermann, R. S. (2013). On the legal issues of teaching evolution in public schools. *The American Biology Teacher*, *75*(8), 539-543.

Hickman, C. P., Roberts, L. S., Keen, S. L., Eisenhour, D. J., Larson, A., & I'Anson, H. (2001). *Integrated principles of zoology* (15th ed.). New York, NY: The McGraw-Hill Companies, Inc.

Hokayem, H., & BouJaoude, S. (2008). College students' perceptions of the theory of evolution. *Journal of Research in Science Teaching*, *45*(4), 395-419.

Hughes, S. W. (1982). The fact and the theory of evolution. *The American Biology Teacher*, *44*(1), 25-32.

Ingram, E. L., & Nelson, C. E. (2006). Relationship between achievement and students' acceptance of evolution or creation in an upper-level evolution course. *Journal of Research in Science Teaching*, *43*(1), 7-24.

Jeffries, J. C., & Ryan, J. E. (2001). A political history of the establishment clause. *Michigan Law Review*, *100*(2), 279-370.

Köse, E. Ö. (2010). Biology students' and teachers' religious beliefs and attitudes towards theory of evolution. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *38*(38), 189-200.

Krupa, J. (2015). *Defending Darwin*. Retrieved from: http://orionmagazine.org/article/defending darwin/

Ladouceur, R. P. (2008). Ella Thea Smith and the lost history of American high school

biology textbooks. *Journal of the History of Biology*, *41*(3), 435-471.

Larson, E. J. (1997). *Summer for the Gods: The Scope's trial and America's continuing debate over science and religion*. New York, NY: Basic Books.

Lawson, A. E., & Weser, J. (1990). The rejection of nonscientific beliefs about life: Effects of instruction and reasoning skills. *Journal of Research in Science Teaching*, *27*(6), 589-606.

Lawson, A. E., & Worsnop, W. A. (1992). Learning about evolution and rejection a \ belief in special creation: effects of reflective reasoning skill, prior knowledge, prior belief and religious commitment. Journal of Research in Science Teaching, 29(2), 143-166.

Lerner, L. S., Goodenough, U., Lynch, J., Schwartz, M., & Schwartz, R. (2012). *The State of State Science Standards, 2012*. Washington, DC: Thomas B. Fordham Institute.

Major, C. H., & Savin-Baden, M. (2010). *An introduction to qualitative research synthesis: Managing the information explosion in social science research.* London, England: Routledge.

McKeachie, W. J., Lin, Y., & Strayer, J. (2002). Creationist vs. Evolutionary Beliefs: Effects on Learning Biology. *The American Biology Teacher, 64*(3), 189-192.

McQuaide, G. G. (2006). An examination of conceptual change in undergraduate biology majors while learning science concepts including biological evolution (doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (UMI No. 305320669).

Meadows, L., Doster, E., & Jackson, D. F. (2000). Managing the conflict between evolution & religion. *The American Biology Teacher*, *62*(2), 102-107.

Miller, J. D., Scott, E. C., & Okamoto, S. (2006). Public acceptance of evolution. *Science 313*(5788), 765-766.

Moon, T. J. (1921). *Biology for beginners*. New York, NY: Henry Holt.

Moore, R. (1999). Creationism in the United States: IV. The aftermath of Epperson v. Arkansas. *The American Biology Teacher*, *61*(1), 10-16.

Moore, R. (2001). The lingering impact of the Scopes trial on high school biology textbooks. *BioScience, 51*(9), 790-796.

Moore, R., Brooks, D. C., & Cotner, S. (2011). The relation of high school biology courses & students' religious beliefs to college students' knowledge of evolution. *The American Biology Teacher*, *73*(4), 222-226.

Moore, R., & Kraemer, K. (2005). The teaching of evolution & creationism in Minnesota. *The American Biology Teacher*, *67*(8), 457-466.

Nadelson, L. S., & Hardy, K. K. (2015). Trust in science and scientists and the acceptance of evolution. *Evolution: Education and Outreach*, 8(1), 9.

National Academy of Sciences. (1998). *Teaching about evolution and the nature of science*. Washington, DC: National Academy Press.

National Research Council. (1996). *National Science Education Standards.* Washington, DC: National Academy Press.

National Science Foundation. (2003). *Characteristics of Recent Science and Engineering Graduates: 2003*. Arlington, VA: National Science Foundation.

National Science Teachers Association. (2010). *National Science Teachers Association position statement*. https://www.nsta.org/about/positions/

Nehm, R. H., Poole, T. M., Lyford, M. E., Hoskins, S. G., Carruth, L., Ewers, B. E., & Colberg, P. J. (2009). Does the segregation of evolution in biology textbooks and introductory courses reinforce students' faulty mental models of biology and evolution? *Evolution: Education and Outreach*, *2*(3), 527-532.

Nehm, R. H., Kim, S. Y., & Sheppard, K. (2009). Academic preparation in biology and advocacy for teaching evolution: biology versus non-biology teachers. *Science Education*, *93*(6), 1122-1146.

Nehm, R. H., & Schonfeld, I. S. (2007). Does increasing biology teacher knowledge of evolution and the nature of science lead to greater preference for the teaching of evolution in schools? *Journal of Science Teacher Education*, *18*(5), 699-723.

Nicholas, C. H. (1965). *Analysis of the course content of the biological sciences curriculum study as a basis for recommendations concerning teacher preparation in biology* (Unpublished doctoral dissertation). Stanford University School of Education, Stanford, California.

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. Washington, DC: The National Academies Press.

Padian, K. (2010). How to win the evolution war: Teach macroevolution! *Evolution Education and Outreach 3*(2), 206-214.

Paterson, B. L., Thorne, S. E., Canam, C., & Jillings, C. (2001). *Meta-study of qualitative*

health research: A practical guide to meta-analysis and meta-synthesis (Vol. 3). Newbury Park, CA: Sage.

Pigliucci, M. (2007). The evolution-creation wars: Why teaching more science is just not enough. *McGill Journal of Education, 42*(2), 285-306.

Pobiner, B. (2016). Accepting, understanding, teaching, and learning (human) evolution: Obstacles and opportunities. *American journal of physical anthropology*, *159*(61), 232-274.

Quessada, M. P., Clement, P., Oerke, B., & Valente, A. (2008). Human Evolution in Science Textbooks from Twelve Different Countries. *Science Education International, 19*(2), 147-162.

Rice, J. W. (2012). *Understanding and acceptance of biological evolution and the nature of science: Studies on university faculty* (Doctoral dissertation). Retrieved from: ProQuest Dissertations & Theses. (UMI No. 3539413).

Rice, J. W., Clough, M. P., Olson, J. K., Adams, D. C., & Colbert, J. T. (2015). University faculty and their knowledge & acceptance of biological evolution. *Evolution: Education and Outreach*, *8*(1), 1-15.

Rice, J. W., Olson, J. K., & Colbert, J. T. (2011). University evolution education: The effect of evolution instruction on biology majors' content knowledge, attitude toward evolution, and theistic position. *Evolution: Education and Outreach, 4*(1), 137-144.

Rosenthal, D. B. (1985). Evolution in high school biology textbooks: 1963-1983. *Science Education*, *69*(5), 637-648.

Rutledge, M. L., & Mitchell, M. A. (2002). High school biology teachers' knowledge structure, acceptance & teaching of evolution. *The American Biology Teacher*, *64*(1), 21-28.

Saini, M., & Shlonsky, A. (2012). *Systematic synthesis of qualitative Research.* Oxford, England: Oxford University Press.

Scott, E.C., & Eldredge, Niles (2004). *Evolution vs. creationism: an introduction.* Westport, CT: Greenwood.

Scott, E. (2004). The creation-evolution continuum: How to avoid classroom conflicts. *Skeptic*, *10*(4), 50-55.

Sewall, G. T. (2005). Textbook publishing. *Phi Delta Kappan, 86*(7), 498-502.

Shapiro, A. R. (2008). Civic biology and the origin of the school antievolution movement. *Journal of the History of Biology, 41*(3), 409-433.

Shankar, G. (1989). *Analysis of factors influencing the teaching of evolution and creationism in Texas public high school biology classes* (Doctoral dissertation). Texas Tech University, Lubbock, Texas.

Sinatra, G. M., Southerland, S. A., McConaughy, F., & Demastes, J. W. (2003). Intentions and beliefs in students' understanding and acceptance of biological evolution. *Journal of Research in Science Teaching, 40*(5), 510-528.

Sinclair, A., Pendarvis, M. P. & Baldwin, B. (1997). The relationship between college zoology students' beliefs about evolutionary theory and religion. *Journal of Research and Development in Education*, *30*(2), 118-125.

Skoog, G. (1969*). The topic of evolution in secondary school biology*

textbooks, 1900-1968 (Unpublished doctoral dissertation). University of Nebraska, Lincoln, Nebraska.

Skoog, G. (1979). Topic of evolution in secondary school biology textbooks: 1900-1977. *Science Education*, *63*(5), 621-640.

Skoog, G. (1984). The coverage of evolution in high school biology textbooks published in the 1980s. *Science Education*, *68*(2), 117-128.

Skoog, G. (2005). The coverage of human evolution in high school biology textbooks in the 20th century and in current state science standards. *Science & Education*, *14*(3-5), 395-422.

Skoog, G., & Bilica, K. (2002). The emphasis given to evolution in state science standards: A lever for change in evolution education?. *Science Education*, *86*(4), 445-462.

Smith, M. U., & Siegel, H. (2016). On the Relationship Between Belief and Acceptance of Evolution as Goals of Evolution Education. *Science & Education*, *25*(5-6), 473-496.

Southerland, S. A., & Scharmann, L. C. (2013). Acknowledging the religious beliefs students bring into the science classroom: using the bounded nature of science. *Theory Into Practice*, (*52*)1, 59-65.

Speake, J. H. (2011). *Evolution/Creationism Controversy: Analysis of Past and Current Policies in Public Schools and the Practice of Allowing Students to Opt-Out of Learning Evolution Concepts* (Unpublished doctoral dissertation). University of South Florida, Tampa, Florida.

Superfine, B. M. (2009). The evolving role of the courts in educational policy: The tension between judicial, scientific, and democratic decision making in Kitzmiller v. Dover. *American Educational Research Journal*, *46*(4), 898-923.

Swarts, F. A. (1991). *Topic and inquiry analysis of the evolutionary content in secondary school biology textbooks of the people's republic of china, the united states of America and the union of soviet socialist republics* (Unpublished doctoral dissertation). Retrieved from: ProQuest Dissertations & Theses Global. (UMI No. 9214038).

Tennessee Anti-Evolution Statute of 1925, HB 185, Tennessee Code Annotated Title 49, Section 1922.

Thorne, S., Jensen, L., Kearney, M. H., Noblit, G., & Sandelowski, M. (2004). Qualitative meta-synthesis: reflections on methodological orientation and ideological agenda. *Qualitative health research*, *14*(10), 1342-1365.

Tracy, S. J. (2010). Qualitative quality: Eight “big-tent” criteria for excellent qualitative research. *Qualitative inquiry*, *16*(10), 837-851.

Truong, J. M., Barnes, M. E., & Brownell, S. E. (2018). Can Six Minutes of Culturally Competent Evolution Education Reduce Students' Level of Perceived Conflict Between Evolution and Religion?. *The American Biology Teacher*, *80*(2), 106-115.

Tulley, M. A. (1985). A descriptive study of the intents of state-level textbook adoption processes. *Educational evaluation and policy analysis*, *7*(3), 289-308.

Walsh, D., & Downe, S. (2005). Meta-synthesis method for qualitative research: a

literature review. *Journal of advanced nursing*, *50*(2), 204-211.

Watt, M. G. (2007). Research on the Textbook Publishing Industry in the United States of America. *Online Submission*, *1*(1), 1-17.

Watts, E., Levit, G. S., & Hoßfeld, U. (2016). Science standards: the foundation of evolution education in the United States. *Perspectives in science*, *10*, 59-65.

Wiles, J. R. (2008). *Factors potentially influencing student acceptance of biological evolution* (Doctoral dissertation). Retrieved from: ProQuest Dissertation Publishing. (UMI No. 66699).

Winslow, M. W., Staver, J. R., & Scharmann, L. C. (2011). Evolution and personal religious belief: Christian university biology-related majors' search for reconciliation. *Journal of Research in Science Teaching*, *48*(9), 1026-1049.

Woods, C. S., & Scharmann, L. C. (2001). High school students' perceptions of evolutionary theory. *Electronic Journal of Science Education*, *6*(2), 1-24.

Woodward, A., & Elliott, D. L. (1987). Evolution and creationism in high school textbooks. *The American Biology Teacher*, *49*(3), 164-170.

Yasri, P., & Mancy, R. (2014). Understanding student approaches to learning evolution in the context of their perceptions of the relationship between science and religion. *International Journal of Science Education*, 36(1), 24-45.

Yates, T. B., & Marek, E. A. (2014). Teachers teaching misconceptions: a study of factors contributing to high school biology students' acquisition of biological evolution-related misconceptions. *Evolution: Education and Outreach*, *7*(1), 7.

VITA

Erin Fucik Childress was born and raised in El Campo, TX. She graduated from El Campo High School in 2005 and earned her BS degree in Biology from Stephen F. Austin State University in 2009. Afterward, she completed and was awarded her Master of Science degree in Biology from Stephen F. Austin State University with a focus on conservation biology. She currently is a Lecturer in the Department of Biology at Stephen F. Austin State University. She is the course coordinator for the Human Anatomy and Physiology content area and teaches Human Anatomy and Physiology courses at Stephen F. Austin State University, as well as being an academic advisor within the Department of Biology and faculty advisor for student led organizations. Additionally, she works part time as a Forestry/Wildlife Technician Contractor with the United States Department of Agriculture Forest Service in Nacogdoches, Texas.

Permanent Address:	347 Scotty Beard Rd., Lufkin, TX 75901
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