ABSTRACT

Dickerson, Daniel Lee. Understanding the Relationship between Science and Faith, the Nature of Science, and Controversial Content Understandings. (Under the direction of Dr. John Penick and Dr. Karen Dawkins).

This study examines the views of the relationship between science and faith and the understandings of biological evolution, geologic history and the nature of science, with emphasis on the use of evidence, held by United Methodist ministers, pre-service science teachers, and pre-service language arts/social studies teachers. By completing a nineteen and a twenty-item, combination multiple-choice/open-ended questionnaire and individual interviews, participants demonstrated a wide array of scientific understandings and articulated in some cases how those understandings inform their views of the relationship between alternative ways of knowing. Findings included little disparity overall between participant groups' scientific understandings, although slightly more ministers demonstrated more informed understandings of the concepts assessed. Additionally, findings indicated that pre-service science teachers viewed scientific literacy as less important than other participant groups and few participants reported any change in their views of science as a result of formal post-secondary instruction. Almost all participants considered evidence to be used in faith but little to no distinction was made between scientific, historical, and faith-based types of evidence. Recommendations are included regarding curriculum development for science teacher and religious education, as well as implications for potential partnerships between the science educators and clergy.
UNDERSTANDING THE RELATIONSHIP BETWEEN SCIENCE AND FAITH,
THE NATURE OF SCIENCE, AND CONTROVERSIAL CONTENT
UNDERSTANDINGS

by

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DEDICATION

This dissertation is dedicated to my daughter, Ashby Ellyn.
I received a BS in Science Education from the University of North Carolina at Chapel Hill in 1998. After obtaining an undergraduate degree, I began teaching at Jordan High School in Durham, NC. In 2000, I entered the graduate program in science education at North Carolina State University. After earning an MS in 2001 and a Ph.D. in 2003, I accepted a position at the College of Charleston.
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Chapter One

Introduction

Few issues in science education elicit more anxiety from classroom teachers, students, administrators, and parents than those embedded with perceived contradictions to one's faith. The undesirable and often volatile stereotypical consequences stakeholders expect as a result of controversial content instruction certainly affect the nature of science instruction, curriculum development, and teacher preparation (Scharmann, 1992). As such, inquiry into the variety of views of the relationship between science and faith is appropriate for science teacher education.

There are a number of ways to approach both science and faith. Either can be considered dogmatic and arrogant to the point where each ignores the value of the other or permissive and all-inclusive to the point where each loses its integrity. This wide range is further complicated by teachers' and students' lack of understanding regarding the nature of science and the variation in levels of personal conviction and personal participation and experiences in the practice of both. The characterization of the atheistic, cynical, radical empiricist scientist arguing nose to nose with the loud, Bible-waving, fundamentalist preacher provides a mental image for many that encapsulates the essence of the science and faith relationship. The notion of conflict between science and faith should be troubling to science educators. Since many teachers and students acknowledge faith as a way of knowing, perceived conflict between the two makes science education for all students a difficult proposition without first addressing the relationship between science and faith. When providing
instruction regarding these two alternative ways of knowing, multiple possible relationships must be examined, not just those of conflict because "most major religions in America are on record as supporting teaching of the scientific methods" and scientific content such as biological evolution and geologic history (Wise, 2001, p30).

The science education community must deal with relationships between science and faith as illustrated by recent decisions made by the Kansas State Board of Education (Helgeson, 2002). Wide variation among the ways teachers and students use alternative ways of knowing to construct an integrated understanding of reality means a one-size-fits-all approach to instruction is not likely to be appropriate. Developing deeper understandings of the ways people view the relationships between alternative ways of knowing is essential to constructing appropriate instructional strategies designed to address controversial content.

**World Views**

The idea of learning taking place in the context of an individual's "world view" helps to further the study of the roles of various ways of knowing in science education (Cobern, 1991, p 7; Cobern, 2000). Many teachers and students engage in the teaching and learning of science but do so from multiple perspectives and through alternative ways of knowing. Studies in science education have identified faith, aesthetics, and science among the many possible ways of knowing used in developing
understandings of controversial content (Dagher & BouJaoude, 1997). Within each of these ways of knowing exists one or more cultures.

**Multiculturalism**

Most definitions of culture involve many of the same components including knowledge, rules, traditions, attitudes, and values used in the development and self-monitoring of behaviors found in a particular group (Betancourt & Lopez, 1993). As such, culture is viewed as a product developed both consciously and serendipitously by a group of people. Group identification is based upon a given characteristic like age, race, sex, religious affiliation, etc. so "we all are influenced by many different cultures" and sometimes "the influences are incompatible or even contradictory" (Woolfolk, 1995, p157). For example, Jackson, Doster, Meadows, and Wood (1995) "view conflicts between religion and science regarding evolution as a bona fide example of a multicultural issue in education".

Modern Western science constitutes a way of knowing about reality that may be inconsistent with many faith-based ways of knowing held by those who practice some Eastern religions. In addition, many Western religious communities also experience conflict between apparent contradictory explanations for natural phenomena. The degree of religious freedom that exists in the United States fosters an unparalleled diversity of religious affiliations and that high degree of religious pluralism does not end at the classroom door (Colburn, 2002).
The idea that cultures of faith operate according to ethics and values seems intuitive, but for some, the same notion applied to science is relatively less so. Some also see science educators as responsible for perpetuating "the failure of science to invest its facts with values, with the consequence that it appears to be ethically and morally detached" (Birch, 1985). In addition, "we try to convince them [students] that science is values free and that its pronouncements are somehow gilt-edged in a way that those of other groups are not" (Baker & Piburn, 1997, p 25). Such a depiction of science is made easier when addressing content like photosynthesis, but as Poole (1990, p 67) points out, "it is hardly necessary to argue the value-laden nature of topics like the use of the environment, origins," and many others. As science educators, we must assist students in constructing appropriate understandings of the nature of scientific culture, including its ethics and values. We must also address the similarities and differences scientific ethics and values have with those of other cultures (e.g. religious groups) in order to equip students with the understandings they need to make informed decisions about societal issues containing scientific components.

Scientific Literacy

Both the Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993) and the National Science Education Standards
(National Research Council, 1996) discuss the importance of distinguishing science from other ways of knowing. These reform and standards documents echo the opinions of many science educators who assert that students need to construct understandings, not only of what makes the domain of science different from other ways of knowing, but specifically what makes it different from faith-based ways of knowing (Reiss, 1992; Loving & Foster, 2000). Understanding how people view the relationship between science and faith becomes crucial to providing meaningful science instruction. Most pre-service teachers, however, receive little or no formal instruction regarding the roles faith-based ways of knowing play in students' construction of scientific understandings and the associated implications for science teaching.

**Research Questions**

While most science educators agree that the influences of alternative ways of knowing on science education are considerable, the natures of those influences remain relatively unknown. This study contributes to the body of literature by further explicating how people view the relationship between science and faith and what consequences exist for science education. Through the use of questionnaires and interviews, data were collected that allow for comparisons to be made between ministers and pre-service teachers in order to address the following research questions:
How do participants' knowledge and beliefs concerning faith and science influence the relationship they see between the two?

a) What understandings of the nature of science do participants hold?

b) What science content understandings do participants hold?

c) In what ways do participants view the relationship between science and faith?
Chapter Two

Literature Review

Research focusing on teachers' and students' understandings of the nature of science and its relationship with other ways of knowing comprises a considerable volume of the literature in science education. Foremost among the relationships addressed are those between science and faith-based ways of knowing. Even with the tremendous amount of work accomplished in this area, many questions still persist including, "How do participants' knowledge and beliefs concerning faith and science influence the relationship they see between the two?" The examination of the following four areas of the literature is essential to understanding the views people possess regarding the relationships between these alternative ways of knowing: 1) Western religions and science, 2) controversial content education, 3) the nature of science in science education, and 4) the nature and roles of evidence as used in various ways of knowing.

Western Religions and Science

Views regarding the relationship between science and faith in Judeo-Christian and Islamic traditions share a number of similarities across religious and denominational boundaries. One of the more striking similarities involves fundamentalist approaches to interpreting religious texts and applying those interpretations in scientific contexts. As such, a view of science and faith as
conflicting explanations for phenomenon commonly occurs in Islam, Judaism, and Christianity. Often, arguments concerning controversial topics like biological evolution that emerge from these different faith systems possess similar characteristics including "motivation", "rhetoric", and rationales (Dagher & BouJaoude, 1997; Dutch, 2002, p 137).

The notion that any one of the three major Western religions, however, holds a singular, homogenous view of the relationship between science and faith is inaccurate (McGrath, 1999). So to say that there are similarities found among the various Western religions is to say that there are similarities found among individual denominations or sects of a particular religion with individual denominations or sects of another religion. A danger of over-generalization still exists, however, due to the variety of views held by members of any given denomination or sect (Goldberg, 1999). The case of Christianity illustrates this point well according to McGrath (1999, p 31):

... the term 'Christian' can refer to a wide variety of intellectual positions, requiring further clarification. Protestant, Roman Catholic, and Eastern Orthodox forms of Christianity are, for example, quite distinct.

McGrath (1999, p 31-44) argues that rather than examining the views of the relationship between science and faith in the context of denomination it may be more appropriate to do so according to the current, most prominent schools of thought in
Christianity. Many scholars recognize the fluid nature of various Christian schools of thought and their ability to flow into and mingle with denominational-specific doctrine resulting in an infinitely diverse array of amalgamated theologies. Carlson (2000, p 11) agrees with the assessment that no one distinct view of the relationship between science and faith should be ascribed to Christianity as a whole or to any given Christian denomination:

I am convinced that there is no single distinctly Christian viewpoint on matters of the relationship of natural science and Christian faith. There are, however, distinct viewpoints held by Christians, and these distinct viewpoints are found in particular Christian subcultures, subtraditions and groups, but these groupings cut across all sorts of Christian boundaries.

While broad similarities may be drawn across religions, denominations and sects within a religion, or particular groupings within a denomination or religion, their usefulness in understanding individuals' views of the relationship between science and faith is limited.
As discussed earlier, scientific and faith-based ways of knowing can both contribute to an individual's worldview. The role that each of those ways of knowing plays and resulting relationships that develop between them determine in part how a student perceives instructional content. For many students, perceiving that instruction is at odds with their current understandings from an alternative way of knowing immediately evokes a competitive environment complete with winners and losers. The winner is the person championing a way of knowing that provides the 'true' explanation, according to the student's definition of truth. The common notion that only one explanation from only one way of knowing can be true makes deciding winners and losers an emotionally-high stakes enterprise for students who ask themselves “Who is telling me the 'truth', my teacher or grandpa?”

In the case of scientific and faith-based ways of knowing, poorly supported construction of concepts that span both ways of knowing potentially creates the dangerous and unnecessary situation of students feeling they must choose between science or faith. A wide range of concepts associated with scientific and faith-based ways of knowing have historically produced societal controversy and internal turmoil. In the context of science education, however, none receive more attention than biological evolution and geologic history.
Biological Evolution

Evolution theory has sparked debate and contention between scientific and religious communities since its birth (Colburn, Henriques, & Clough, 2002; Passmore & Stewart, 2002; Brem, Ranney, & Schindel, 2003). In no way immune, the science education community in the United States experienced similar turmoil over the past century regarding the inclusion and treatment of this controversial content (Moore, 1984; Skehan & Nelson, 2000). Nelkin (1977) and Matsumura (1998) have highlighted the long and on-going procession of anti-evolution legislation introduced into American courts. In addition, many Americans believe an alternative creation account not supported by scientific methods or evidence (Colburn, et al., 2002; Brazelton, Frandsen, McKown, & Brown, 1999; Jackson, et al., 1995).

Despite the public's apparent lack of support for evolution theory, the scientific community, almost without exception, embraces evolution and has helped foster its emergence as one of the fundamental concepts in the biological sciences (Dobzhansky, 1973; Mayr, 1982; National Academy of Sciences, 1998; Passmore & Stewart, 2002). Most science educators, in this instance, have aligned themselves with the scientific community and acknowledge the importance of evolution theory to the teaching and learning of many biological concepts. The science education community's commitment to providing instruction regarding evolution is evidenced in the National Science Education Standards (National Research Council, 1996) and other standards documents.
Teachers and students, however, often experience "frustration" and receive "criticism" for engaging in instruction of evolution theory (Scharmann, et al., 1992). In addition, research findings show that teachers and students hold inappropriate understandings of evolution concepts before and after interventions (Brumby, 1984; Clough & Wood-Robinson, 1985; Jensen & Finley, 1996; Helgeson, et al., 2002). As a result, the fruit of numerous efforts to improve instruction of evolution concepts fills the literature. A few of the varied instructional approaches include those that: require total exclusion of other ways of knowing, confront conflict by making use of argumentative strategies, and include discussing the relationships of other ways of knowing (Kemp, 1988; Moshman, 1985; Nelson, 1986; Seaford, 1990; Scharmann, 1990; Scharmann et al., 1992; Simpson & Anderson, 1992).

**Geologic History**

Just as with biological evolution, geologic history often serves as a catalyst for conflict in the science classroom (Brand, 1997; Wise, 2001). Since "geology is the science with the clear focus on deep time", people who hold beliefs that preclude an earth time scale on the order of billions of years consider many aspects of the discipline naïve (Trend, 2000, p 541). Evolution theory, however, emerges as the content of choice in debates fueled by views of incompatible ways of knowing. Two possible reasons exist for geology’s frequent escape from the battle. The first involves the often oversimplified and many times erroneous implications of biological evolution portrayed in the popular media. Natural selection, not bedrock,
is often depicted as responsible for altruistic and violent behavior, human health, love
and lust, as well as issues of race (Daly & Wilson, 1988, 1992; Dawkins, 1976;
issues generally touch our emotions because they encroach on understandings
founded through ways of knowing other than science. The second possibility
involves issues of generalized scale usually associated with the two disciplines of
science. Unlike evolution theory that requires understanding the possible reasons and
implications of changes in gene frequency over time, many tenets of geology are
based on directly observable events, which are then applied through processes of
retrodiction. For example, noting changes in eye color of members of a family over
generations intuitively indicates that something is happening in the process of
reproduction, but since the causes are directly unobservable, understandings of
genetics more sophisticated than those possessed by the majority of the public
becomes necessary. In contrast, for most people the presence of seashells indicates
marine inundation whether they are embedded in a particular stratum of rock 2000
feet in elevation or found close to present-day sea level. The reason lies in peoples'
experiences of directly observing that seashells are found around marine
environments. The difference in the generalized macro and micro scales of geology
and biological evolution respectively may account for the disparity found in the
intensity of adverse sentiment towards instruction of related content.

Enough conflict is experienced during instruction of geologic history,
however, to prompt articles addressing instructional strategies to stem confrontation.
For example, Wise (2001, p 30) describes how he attempts to defuse possible confrontations:

*For a geology course, I broach the evolution/creationism problem at the first class noting that there are many views of Earth history beside the geologic one. These include a variety of religious-based views ranging from native American beliefs to the Biblical version involving Noah's flood and a 6000 year age of the Earth. Further, if there are any students of these persuasions in the class, the only course requirement is that they know the arguments and evidence which form the basis of the scientific viewpoint. What they actually believe is entirely up to them. This usually defuses the worst initial reactions.*

This excerpt serves as an example of how teachers might view the inclusion of controversial content as something to survive rather than an opportunity to teach students about the uniquely valuable characteristics of science as a way of knowing.

**The Nature of Science in Science Education**

Virtually every major standards and reform-based document used today comments on the importance of the nature of science in science education; however a
consistent characterization of that nature is nowhere to be found (Good & Shymansky, 2001). The epistemological, ontological, and axiological inconsistencies found within and across documents illustrate the multitude of acceptable and/or frequently espoused views within the philosophical, scientific, and educational communities concerning science as a way of knowing. Navigating the often muddy waters of the nature of science lexicon means appropriately identifying and decoding words and phrases that: 1) can be used differently in varying contexts (e.g. externalism), 2) sometimes vary dramatically in definition based upon the author's perspective, and 3) are not provided in a comprehensive way for a given context. Despite the complexity of the subject, especially in the context of philosophy of science, the literature identifies important ideas about the nature of science that contribute to scientific literacy without diverging into esoteric ideas that have little value or interest for teachers and students.

Regardless of which acceptable views researchers take, findings consistently show that teachers and students hold incomplete and inappropriate understandings of various aspects of the nature of science that are widely accepted within scientific culture, such as: 1) the nature and roles of theories and laws, 2) the tentative nature of science, and 3) the existence of multiple scientific methods (Driver, Leach, Millar, & Scott, 1996; Lederman, 1992; McComas, 2001a). Science educators have proposed a variety of instructional strategies to remedy the lack of understanding in this area. Some of the more popular strategies include engaging in authentic scientific practice, the study of the history of science, conducting visualization activities and games, cooperative argumentation, and lecture (For examples, see McComas, 2001b). Each
activity can potentially be taught implicitly or explicitly; however, most science educators believe that explicit instruction is more effective (Lederman & Abd-El-Khalick, 2001).

Evidence

The inappropriate application of concepts of evidence affects scientific understandings as well as views of relationships between scientific and alternative ways of knowing. Teachers and students are bombarded with descriptions of evidence as used in a wide variety of different cultures and contexts. The unfortunate result is people develop an amalgamated concept of evidence derived from a variety of disciplines, which is usually not an appropriate understanding for use in a scientific context. The failure to differentiate between types of evidence, however, means people often apply whatever concept of evidence they possess in the same manner across multiple ways of knowing. Although the concept of evidence is used in variety of contexts, this paper focuses on the domains of science, history, and faith.

Science

"Evidence is a concept central to the empirical sciences. Whether to believe, or even take seriously, a scientific hypothesis or theory depends on the quantity and character of the evidence in its favour" (Achinstein, 1983, p 1). The science education community agrees and subsequently considers instruction regarding
Evidence important in the development of a scientifically literate person (National Research Council, 1996; Skehan and Nelson, 2000). When discussing the nature and role of scientific evidence, however, several problematic issues immediately arise. Evidence as used in science varies considerably dependent upon the particular culture of a given discipline and the epistemological stance of the individual (Kourany, 1998). Furthermore, practicing scientists and philosophers of science describe evidence differently within the same discipline and operating under the same epistemological framework (Achinstein, 2001). So some have suggested discussing the concept of scientific evidence in terms of its similarities among the various disciplines of science (Kuhn, Amsel, and O'Loughlin, 1988). In science education, a scientifically generalized view of evidence stands as the present paradigm in both curriculum and instruction. In addition, evidence, in part due to its very nature, is almost always discussed in relation to scientific theory and method, making the processes by which it is identified its defining characteristics. As such, many researchers and curriculum developers have focused their attention on developing students' abilities to interpret and use evidence appropriately (Robertson, 1999). Most intervention occurs in the context of a larger unit regarding the nature of science, and so occurs during activities designed to provide students with more complete and appropriate understandings of the nature of science as a whole. As a result, interventions vary little from those described earlier in this paper.
History

Just as with the domain of science, historians make use of evidence and the nature and role of that evidence varies within the domain (Shafer, 1974). The same reasons of epistemological stance, membership in a discipline-specific culture, and differences between practitioners and philosophers, partially account for the discrepancies. Jordanova (2000, p 100) describes this variation, in part, below:

*I am suggesting that there are many ways of knowing; sometimes they become so entangled that it is difficult to be clear about the epistemological claims involved. I have evoked these diverse ways by referring to notions, such as information, insight, explanation, understanding and wisdom, that are all linked to knowledge in some way. Whereas gathering information implies collecting and organizing data, wisdom implies the accumulation of human experience and the ability to discern and comprehend its main patterns. Disciplines vary in the value they give to these different forms of knowing. What makes the status of historical knowledge a particularly complex matter is that it is a subtle blend of all these ways.*
The focus of that compilation of various ways of knowing centers on developing accurate understandings of human societies (Abbott, 1996). This focus impacts both the nature and use of evidence. For example, Jordanova (2000 p 33) describes the nature of historical evidence below:

The materials from which history is made are, therefore, diverse and we need to be able to appreciate the richness and the limitations of each type. One characteristic of outstanding historical scholarship lies in the creative and self-aware use of the complexities of evidence. This involves conveying to readers something of the processes by which sources have been produced, so that they are not presented as static documents with self-evident authority, but rather emerge as layered assemblages that testify in a variety of ways.

More specifically, historical evidence is usually embodied in written documents, although oral (e.g. folklore, ballads, etc) and physical evidence (e.g. pottery, tools, etc) are widely used in a number of disciplines of history (Arnold, 2000). Regardless of the type of evidence, one of the primary responsibilities of the competent historian is to mentally reconstruct the circumstances that influenced the development of the source being used as evidence. Furthermore, historians use the reconstructed influences they imagined and deemed probable in conjunction with the actual source
to arrive at a conclusion (Jordanova, 2000). They also make use of three other important methods when dealing with evidence, namely external criticism, internal criticism, and synthesis. External criticism allows an individual to draw conclusions regarding the authenticity of the evidence. Internal criticism revolves around the notion of credibility of the evidence and synthesis is the blending of various pieces of evidence to reconstruct a historical event (Shafer, 1974).

Faith

Evidence as used in faith often bares close resemblance to that of historical evidence, especially focusing on the authenticity and credibility of sources. In the context of Christianity, there exist two primary reasons for the close connection between the two. First, one of the centerpieces of Christianity is the Bible, a document often used as historical evidence of one type or another and secondly, Christians' interests in reconstructing human society in a distinct time and place. Often, historians compare Biblical accounts with other documents (e.g. Dead Sea Scrolls) to reach conclusions concerning the accuracy of a given source as in Van Voorst's (2000) *Jesus Outside the New Testament: An Introduction to the Ancient Evidence*. Furthermore, some have applied the methods of external and internal criticism to books of faith (McDowell, 1972). Yet evidence applied in faith assumes many other forms than those characteristic of historical evidence.

Many types of evidence exist in faith and are usually detailed through apologetics, which can be characterized as providing evidence for belief in the
Christian faith (Geisler, 1999). Additionally, experience serves as an important source of evidence in faith (Nathan, 1980) along with a range of other types of evidence including but not limited to rational, historical, prophetic, mystical, presuppositional, and archeological (Geisler, 1999). Archeological evidence perhaps comes close to constituting the use of scientific evidence in faith, since many archeologists routinely employ tools and techniques associated with scientific endeavor (Magnusson, 1977). Some claim scientific evidence as capable of appropriate use in issues of faith. For example, Morris (2002) provides a geology textbook that embraces a literal interpretation of the Bible and presents what he considers scientific evidence for a six-day creation.
Understanding the views held by ministers regarding faith as an alternative way of knowing about reality are important for science educators. When we address issues related to the relationship between science and faith, "the widespread failure to understand how religions regard their doctrines frequently results in miscommunication and ineffective, even counter-productive, strategies" (Dutch, 2002, p 137). In addition, ministers, by virtue of their religious education and professional practice, should in general, hold deeper understandings about the nature of faith as compared to other groups. Operating under this assumption, I developed and implemented methodologies to first collect data regarding ministers' understandings of scientific and faith-based ways of knowing as well as their views on the relationship between the two. I then applied the conclusions drawn from these data to inform the development and implementation of methodologies to collect data regarding pre-service teachers' understandings of 1) biological evolution and geologic history, 2) the nature and role of evidence, and 3) their views of the relationship between science and faith. The study involves pre-service secondary teachers from the areas of science and language arts/social studies. The inclusion of pre-service teachers from different educational domains stems from the idea that evidence plays important roles in a variety of academic disciplines, yet within each discipline the nature of evidence can differ dramatically. Consequently, pre-service teachers'
abilities to distinguish scientific evidence from other types of evidence may play an important role in their views of the relationship between science and faith.

Methodology Used with Clergy

I looked at recent studies conducted by Colburn, Henriques, Clough (2002), Jackson (2002), and others to assist me in developing an instrument to reveal ministers' understandings of the relationship between science and faith. In particular, I modeled this study after the work of Colburn et al. (2002) but made some significant changes with respect to the structure and content of the instrument and participant selection. The changes included limiting the range of participants' religious affiliations, increasing the sample size, and devoting more attention to participants' understandings of the nature of science.

The Instrument

I developed an instrument composed of five multiple-choice items, ten combination multiple-choice/short answer items, one fill in the blank item (in the form of a timeline), and four open-ended items for a total of twenty items (Appendix A). The large number of items containing an open-ended response component stems from research suggesting there are problems associated with interpreting multiple-choice items regarding the nature of science (Lederman, Wade, & Bell, 1998). The first three items ask for participant background information, including age, number of
years as a minister in the United Methodist Church (UMC), and number of science courses taken beyond general college science requirements. Item 4 asks participants to rate their own knowledge of science, while item 5 inquires about the role of seminary/divinity school in shaping their understandings of science. The remaining items fall in one of four categories: 1) scientific content understanding, 2) ministers' role(s) in shaping their congregations' notions of the relationship between science and faith, 3) ministers' understandings of the nature of science, and 4) ministers' notions regarding the relationship between science and faith (Table 1).

Table 1. Categorization of Minister Instrument Items (See Appendix A for Actual Instrument)

<table>
<thead>
<tr>
<th>Category</th>
<th>Item and Number on Questionnaire</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background information</td>
<td>1. Age?</td>
<td>1. Multiple-choice</td>
</tr>
<tr>
<td></td>
<td>2. How many years have you been a UMC pastor?</td>
<td>2. Multiple-choice</td>
</tr>
<tr>
<td></td>
<td>3. Did you take any science courses beyond your general college science requirements? If yes, how many semester courses beyond required?</td>
<td>3. Combination multiple-choice/ short answer</td>
</tr>
<tr>
<td>Self-reporting of level of scientific knowledge</td>
<td>4. How would you rate your knowledge of science?</td>
<td>4. Multiple-choice</td>
</tr>
<tr>
<td>Role of seminary/divinity school</td>
<td>5. Did your view of science change as a result of attending Seminary/Divinity School? Comments/Explanation:</td>
<td>5. Combination multiple-choice/ short answer</td>
</tr>
</tbody>
</table>
Table 1. (Continued)

<table>
<thead>
<tr>
<th>Scientific content understandings</th>
<th>13. Please place the following with approximate dates (if possible) on the timeline below: dinosaurs, formation of the Earth, people, birth of Jesus Christ, formation of the universe, first appearance of bacteria on Earth</th>
<th>13. Fill in the blank (timeline)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18. What is evolution and what do you think about it?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ministers' role(s) in shaping congregations' understandings of the relationship between science and faith</th>
<th>11. Do you address current scientific issues with church members? If so, give examples:</th>
<th>11. Combination multiple-choice/ short answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. In general, do you think that your congregation thinks about science and religion in the same way you do? Comments/Explanation:</td>
<td>12. Combination multiple-choice/ short answer</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ministers' understandings of nature of science</th>
<th>9. Please mark true or false (T or F) to indicate your beliefs:</th>
<th>9. Multiple-choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. _____ Scientific theories are often not very reliable.</td>
<td>10. Multiple-choice</td>
<td></td>
</tr>
<tr>
<td>b. _____ If a theory holds up over time, it may become a scientific law.</td>
<td>17. Open-ended</td>
<td></td>
</tr>
<tr>
<td>c. _____ Most scientists relate their research to existing theories.</td>
<td>19. Open-ended</td>
<td></td>
</tr>
<tr>
<td>10. For the statements below, choose A, B, or C for the response closest to what you believe. (A = theory; B = law; C = both)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. _____ An explanation for a natural phenomenon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. _____ Most often related to physics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. _____ Can usually be expressed mathematically</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. _____ Supported by evidence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. _____ Useful in predicting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. How would you define science?</td>
<td>9. Multiple-choice</td>
<td></td>
</tr>
<tr>
<td>b. What role does it play in science?</td>
<td>17. Open-ended</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19. Open-ended</td>
<td></td>
</tr>
</tbody>
</table>

25
Table 1. (Continued)

| Ministers' understandings of the relationship between science and faith | 6. Do you believe a Christian can be a scientist and remain faithful? Comments/Explanation: | 6. Combination multiple-choice/ short answer |
| | 7. Do you believe a scientist can be a Christian? Comments/Explanation: | 7. Combination multiple-choice/ short answer |
| | 8. Is it important for a Christian to be scientifically literate (that is, have a basic understanding of how science works)? Comments/Explanation: | 8. Combination multiple-choice/ short answer |
| | 14. Do you see a relationship between science and faith? If yes, explain: | 14. Combination multiple-choice/ short answer |
| | 15. Do you think there any contradictions between science and religion? If yes, give examples: | 15. Combination multiple-choice/ short answer |
| | 16. How does your knowledge level of science affect your religious views? | 16. Open-ended |
| | 20. Is evidence used in faith? If yes, give examples: | 20. Combination multiple-choice/ short answer |

The Participants

The participants consisted of sixty-three United Methodist ministers of whom seventy-eight percent were younger than sixty years old (Fig. 1). Additionally, sixty-seven percent of the participants served less than twenty years as a minister in the United Methodist Church, however, the study included participants in each time-bracket (Fig. 2).
All participants are currently ordained or in the process of becoming ordained in the United Methodist Church. One rationale guiding the choice of United
Methodist ministers as the participants for the study included the relative consistency in their educational backgrounds. As part of ordination, potential ministers must successfully complete a degree program from a recognized seminary or divinity school. Acceptance to a recognized seminary or divinity school requires an undergraduate degree from a four-year post-secondary institution. I also wanted to include United Methodist ministers because of the church's official stance towards science as described, in part, in the Social Creed of the UMC (Watts, 2002, p 65):

\textit{We affirm the natural world as God's handiwork and}
\textit{dedicate ourselves to its preservation, enhancement, and}
\textit{faithful use by humankind.}

In this portion of the creed, the United Methodist Church describes a clear relationship between our natural environment and God. Dependent upon the understanding held by the developers of the creed concerning the nature of science, this sentence may also consciously articulate a particular relationship between science and faith. The description of the "natural world" as "God's handiwork" suggests a perfect craftsman/craft relationship between God and nature, since United Methodists hold God to be 'perfect' and all He creates as 'good'. Additionally, the last part of the sentence possibly includes the processes of science, as all members of the Church are to serve as stewards of God's creation in order to assist in its "preservation, enhancement, and faithful use". Science would supply an effective means by which to attempt to preserve and enhance our natural environment, while faithfully
operating according to God's will. This is only one possible interpretation. The wording provides ample room for individual ministers to interpret in a broad number of ways. More importantly, however, the Social Creed does not prevent clergy or laity from forming any particular type of relationship between science and faith so long as God is viewed as the Creator.

Lastly, there exists wide variety among United Methodists concerning individual theological perspectives. The United Methodist Church's acknowledgement of such variety among its members is captured in part in the following statement:

And in the area of doctrine, some United Methodists believe only what the Bible says, while others say the Bible can best be understood when it is illumined by tradition, brought alive through personal experience, and confirmed by reason (Watts, 1998 p 8).

It becomes reasonable then to assume that many of the major schools of Christian thought (i.e. liberal protestantism, modernism, neo-orthodoxy, and evangelicalism) be present in a large sample of United Methodist ministers. Rather than collecting large samples from a variety of Christian denominations where one or two particular schools of thought may be the only ones voiced, I decided to select a denomination that openly supported the discussion of many different schools of thought. As such, the United Methodists provide diverse theological perspectives that may or may not
translate into diverse views regarding the relationship between science and faith. The diversity of views in an otherwise relatively homogenous grouping potentially allows for the identification of trends based upon a given variable.

Data Collection and Analysis

I distributed the instrument to ministers at the North Carolina Annual Conference of the United Methodist Church in two ways. I set up a booth at which I maintained a presence displaying a poster describing the study and handed out the instrument to ministers who passed by me. I also placed stacks of the instruments in various locations throughout the conference center with signs posted on the walls indicating where to place completed instruments. A collection box located at the booth served as the depository for all completed instruments. Data collection occurred over the course of two days, except in the case of two participants who completed an electronic version of the instrument I sent to them via email per their request. With the exception of the emailed instruments, all data collected was anonymous.

Data analysis involved quantitative and qualitative components. Circled responses from multiple-choice and combination multiple-choice/short answer items were aggregated and tallied. I used the tallied choices to calculate percentages of each response for each item. Comparisons were made across and within items. I coded and aggregated participants' responses to the open-ended portions of the items to illuminate trends and supported my assertions with selected responses.
Methodology Used with Pre-Service Teachers

The methodology used with the United Methodist ministers supplied a wealth of data regarding their understandings and views concerning various aspects of and relationships between science and faith. The successful nature of the questionnaire employed in the initial portion of this study prompted me to use it with the pre-service teachers also. Due to the participant-specific nature of some items, however, alterations ranging from semantics to deletion and development of new items became occasionally necessary. Additionally, I audio taped and transcribed interviews with selected pre-service teachers to gain further insight into their understandings and views of various ways of knowing. United Methodist ministers receive training in and regularly practice articulating their views of faith in both written and verbal forms, whereas pre-service teachers may not have ever communicated their thoughts about this particular way of knowing. I included the interviews in order to provide pre-service teachers the opportunity to further explain their ideas, in perhaps a variety of ways, rather than restricting them to describing their views in a concise written form.

The Instrument and Interview Protocol
I administered an instrument (Appendix B) to pre-service teachers similar to the one used with the ministers (Appendix A). The instrument contains three multiple-choice items, ten combination multiple-choice/short answer items, one fill in the blank item (in the form of a timeline), and five open-ended items for a total of nineteen items (Appendix B). The first two items ask for participant background information, including the participant's tracking number, college major, and area of concentration (e.g. Major - science; Concentration - Biology). A tracking number was used to protect student confidentiality. A master list of tracking numbers and student names was kept separate from the data and no student names appeared directly on any surveys. Item 3 asks participants to rate their own knowledge of science, while item 4 inquires about the role of university coursework in shaping their understandings of science. The remaining items fall in one of four categories: 1) scientific content understanding, 2) understandings of the nature of science 3) the nature and role of evidence, and 4) notions regarding the relationship between science and faith (Table 2).

Table 2. Categorization of Pre-Service Teacher Instrument Items (See Appendix B for Actual Instrument)
<table>
<thead>
<tr>
<th>Category</th>
<th>Item</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background information</td>
<td>1. Tracking number</td>
<td>1. Fill in the blank</td>
</tr>
<tr>
<td></td>
<td>2. Are you a science or history/social studies education major? What is your area of concentration?</td>
<td>2. Combination multiple-choice/ short answer</td>
</tr>
<tr>
<td>Self-reporting of level of scientific knowledge</td>
<td>3. How would you rate your knowledge of science?</td>
<td>3. Multiple-choice</td>
</tr>
<tr>
<td>Role of university coursework</td>
<td>4. Did your view of science change as a result of attending university courses? Comments/Explanation:</td>
<td>4. Combination multiple-choice/ short answer</td>
</tr>
<tr>
<td>Scientific content understandings</td>
<td>12. Please place the following with approximate dates (if possible) on the timeline below: dinosaurs, formation of the Earth, people, birth of Jesus Christ, formation of the universe, first appearance of bacteria on Earth</td>
<td>12. Fill in the blank (timeline)</td>
</tr>
<tr>
<td></td>
<td>17. What is evolution and what do you think about it?</td>
<td>17. Open-ended</td>
</tr>
<tr>
<td>Understandings of nature of science</td>
<td>9. Please mark true or false (T or F) to indicate your beliefs:</td>
<td>9. Multiple-choice</td>
</tr>
<tr>
<td></td>
<td>a. ______ Scientific theories are often not very reliable.</td>
<td>10. Multiple-choice</td>
</tr>
<tr>
<td></td>
<td>b. ______ If a theory holds up over time, it may become a scientific law.</td>
<td>16. Open-ended</td>
</tr>
<tr>
<td></td>
<td>c. ______ Most scientists relate their research to existing theories.</td>
<td></td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
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<td></td>
<td>d. ______ Supported by evidence</td>
<td></td>
</tr>
<tr>
<td></td>
<td>e. ______ Useful in predicting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16. How would you define science?</td>
<td></td>
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<tr>
<td></td>
<td>19. Combination</td>
<td></td>
</tr>
<tr>
<td>Understandings of the relationship between science and faith</td>
<td>5. Would you consider yourself to be a person of faith? Comments/Explanation:</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Do you believe a person of faith can be a scientist and remain faithful?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comments/Explanation:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Are scientific issues addressed in your place of worship? If yes, give examples and state whether the scientific content is explained in the same way as in science courses you may have taken:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Is it important for a person of faith to be scientifically literate (that is, have a basic understanding of how science works)? Comments/Explanation:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11. In general, do you think that your students will think about science and religion in the same way you do? Comments/Explanation:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13. Do you see a relationship between science and faith? If yes, explain:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14. Do you think there any contradictions between science and religion? If yes, give examples:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15. How does your knowledge level of science affect your religious views?</td>
<td></td>
</tr>
</tbody>
</table>

I developed the interview protocol (Appendix C) as a means of gaining a deeper understanding of at least some participants' views regarding the relationship between science and faith. Protocol questions focus on participants' responses to questionnaire items. In particular, the interviews are designed to illuminate participant use of evidence and their understandings of the nature of science. Questions 1, 2, and 4 provide opportunity for examination of the pre-service teachers'
use of scientific evidence in the contexts of geologic history and evolution theory.
The remaining three questions collectively inquire about participants' ideas regarding whether the nature and role of evidence changes in varying contexts. I conducted the interviews, which lasted approximately one hour, with each participant individually.

The Participants

The study focused on two groups of pre-service secondary teachers: 1) twenty-seven pre-service science teachers and 2) seven pre-service language arts/social studies teachers. The small sample sizes are a reflection of student enrollment. Pre-service science teachers consisted of sophomores, juniors, seniors, post-baccalaureate, and licensure only students and represented a range of concentrations (minors) as illustrated in Figures 3 and 4. The pre-service language arts/social studies teachers were all seniors preparing to teach middle grades (6th - 8th grade). Additionally, all participants, with the exception of one pre-service science teacher, considered themselves to be a "person of faith". That one participant provided the following explanation: "I am an agnostic." Five pre-service teachers, however, circled the response "N/A" for Item 7 regarding a place of worship including the one participant that indicated that he/she was not a "person of faith". One such participant explained their choice of "N/A" with the following statement: "I do not participate in organized religion." While the vast majority of participants indicated that they considered faith as a way of knowing about reality, the degree and orientation of that faith varied.
The rationale behind the selection of the two groups primarily revolves around the notion that the scientific community and historians both use evidence in their disciplines, but the nature of that evidence differs. Assuming that through the study of science or history/social studies, each participant constructed understandings of the nature and roles their discipline's community attributes to evidence. If the participants' understandings are appropriate relative to those held by their discipline's community at large, then the two groups may describe evidence differently from one another. This difference in the conceptualization of evidence may influence participants' views concerning the relationship between different ways of knowing that use evidence (e.g. science and faith).

Figure 3. Pre-service Science Teachers' Class
Figure 4. Pre-service Science Teachers' Concentration

The group of four pre-service teachers that participated in interviews consisted of three concentrating in science and one in language arts/social studies (Table 3). Two were male and of those, one a junior and one a senior. Both of the male pre-service teachers majored in science education and I characterized them as traditional in age. I define traditional as the average age of a student who would enter post-secondary education immediately after high school. Of the male pre-service teachers, one concentrated in middle school science and the other in chemistry. The other two pre-service teachers were senior, females who I characterized as mature in age. A mature student would have entered their current educational program later in life than the average traditional student. One majored in science education and the other in language arts/social studies education. The science education major chose Biology as
her concentration and the other middle school language arts/social studies. All interview participants identified themselves as being people of faith and having a 'good' understanding of science.

Table 3. Summary of Demographics of Pre-service Teachers Interviewed

<table>
<thead>
<tr>
<th></th>
<th>Student A</th>
<th>Student B</th>
<th>Student C</th>
<th>Student D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td>Male</td>
<td>Male</td>
<td>Female</td>
<td>Female</td>
</tr>
<tr>
<td><strong>Class</strong></td>
<td>Junior</td>
<td>Senior</td>
<td>Senior</td>
<td>Senior</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>Traditional</td>
<td>Traditional</td>
<td>Mature</td>
<td>Mature</td>
</tr>
<tr>
<td><strong>Major</strong></td>
<td>Science</td>
<td>Science</td>
<td>Science</td>
<td>Social Studies</td>
</tr>
<tr>
<td><strong>Concentration</strong></td>
<td>Middle School Science</td>
<td>Chemistry</td>
<td>Biology</td>
<td>Middle School Social Studies</td>
</tr>
<tr>
<td><strong>Person of Faith</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Knowledge of Science</strong></td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
</tbody>
</table>

Data Collection and Analysis

I administered a questionnaire instrument (Appendix B) during the pre-service teachers' education courses. Data analysis involved quantitative and qualitative components. Circled responses from multiple-choice and combination multiple-choice/short answer items were aggregated and tallied. I used the tallied choices to calculate percentages of each response for each item. Comparisons were made across and within items, as well as, across comparison groups. I coded and aggregated participants' responses to the open-ended portions of the items to illuminate trends and supported my assertions with selected responses. All data collection occurred over the course of three weeks. The participants completed the questionnaire before
the start of one of their education classes. I made participants aware that the
instrument was in no way related to their course grade and their participation was
completely voluntary.

Selected students were also interviewed and asked about their understandings
of the nature of science, biological evolution, geologic history, and the relationship
between science other ways of knowing (e.g. faith) (Appendix C). I selected all
participants that volunteered for the interviews yielding three pre-service science
teachers and one pre-service language arts/social studies teacher. All interview
participants indicated on their surveys that they considered faith as a way of knowing.
The interviews were audiotaped and transcribed and the data were coded and
aggregated. In addition, I used selected responses as evidence for conclusions drawn.
Ministers’ Educational Backgrounds

The Methodology portion of the paper contains the results from Items 1 and 2 because the responses pertained solely to participant demographics. Item 3 inquired about participant's science coursework background. Slightly less than half of the sixty-three participants, 49%, indicated that they had taken science courses beyond their general college science requirements. Of those thirty-one participants, two (6%) did not respond to the follow-up question of "If yes, how many semester courses beyond required?" Nine (29%) provided verbal responses including the following: "minored in Zoology" , "MS Biology" , "math major minor in physics" , "PhD in chemistry" , "BA in chemistry" , "many" , "PhD in physics" , "BS" , and "PhD in economics". The rest of the responses were numerical and ranged from one to fifty with a mean of 6.57, median of 3, and a standard deviation of 10.61.

All sixty-three participants responded to the item concerning their knowledge of science. Almost all of the participants, 94%, rated their own knowledge of science as "good" or "very good". Only 6% rated their knowledge as "poor" and no one rated their knowledge as "very poor" (Fig. 5).
Figure 5. Comparison of Self-Reported Knowledge Level of Science

Pre-service Teachers' Educational Backgrounds

The demographic information supplied in Items 1, 2, and 5 of the questionnaire (Appendix B) regarding tracking number, major, concentration, and acknowledgment of faith as a way of knowing about reality appear in the Methodology portion of the paper. All pre-service teachers responded to Item 4, which required them to self-assess their level of knowledge of science. All pre-service science teachers rated their knowledge of science as either "good" (67%) or "very good" (33%). In contrast, of the seven pre-service language arts/social studies teachers, one rated his/her knowledge as "poor" (14%), four "good" (57%), and two "very good" (29%) (Figure 5).
Most ministers and pre-service teachers completed item 13/12 (Appendix A/B), which required participants to place events on a timeline. Fourteen ministers and two pre-service science teachers either provided an alternative response or choose not to answer. For example, one minister responded by writing:

*The physical formation of the universe and the Genesis stories are not incompatible. They speak at different levels. One seeks the date of existence, the other its meaning. The Genesis stories were never intended to be a scientific explanation and we do a disservice to the stories to make them so.*

The pre-service teacher that provided an alternative response wrote, "Not sure". I sorted the remaining responses into three categories: 1) completed timeline, 2) completed timeline with times provided by relative spacing, and 3) completed timeline with times provided by absolute dates. I then sorted each category by appropriate and inappropriate responses, with an appropriate response being one currently accepted by the scientific community at large. Appropriate dates were deemed those that fell within the range of dates currently accepted by the scientific community at large for the beginning and ending of a given event. Responses from ministers in Category 1 included twenty appropriate and eight inappropriate responses. Three of these participants provided additional commentary on their
timelines. One minister who provided an inappropriate response placed the "creation account" occurring at the same time as the events "people" and "the first appearance of bacteria on Earth" (See Fig. 6).

Figure 6. Creation Account

Two other ministers who provided appropriate responses wrote the following concerning the item and their responses:

\[\text{Dates are not an issue with me.}\]

\[\text{I believe the Biblical account of creation, but I'm not convinced it took a literal week. I get frustrated when scientists dismiss God out of hand....They (and we) should not pretend to know more than we do.}\]

Category 1 included sixteen responses from pre-service science teachers. Of those sixteen, nine were inappropriate. Four of the responses deemed inappropriate
were identified as such because the respondent failed to include all the items in the timeline. The other five inappropriate responses included events placed out of order such as "dinosaurs" placed before "bacteria". One response placed the "formation of the universe" and the "formation of the earth" as occurring simultaneously. Lastly, one participant indicated that dinosaurs should not appear on the timeline because they never actually existed as evidenced in Figure 7 below:

![Figure 7. World without Dinosaurs](image)

Also included in Category 1 are four of the seven responses provided by the pre-service language arts/social studies teachers. All four responses were appropriate.

Category 2 included six appropriate and one inappropriate response from the ministers. The one inappropriate response contained additional commentary as well, combining all of the events except the "birth of Jesus Christ" at the beginning of the timeline, and marking the end as "Today" (See Fig. 8).
The appropriate responses from the minister in Category 2 include those with appropriate relative times and inappropriate relative times. Two of the six responses were appropriate in both terms of the sequence and the relative spacing of the events, as in Figure 9.

Only one pre-service science teacher and no pre-service language arts/social studies teachers gave responses classified as Category 2. The one response from the pre-service teacher was considered appropriate with inappropriate relative spacing.

Category 3 included four inappropriate and ten appropriate responses from ministers. The four inappropriate responses were labeled as such because the participants left out one of the events in their timelines. The ten appropriate responses
were further sorted based upon appropriate sequencing only as opposed to appropriate sequencing and dates. Seven participants provided responses that were appropriate in terms of sequencing and three provided responses with appropriate sequencing and dates.

Pre-service science teachers provided eight responses that included absolute dating. Of those eight, three were considered to have appropriate sequencing and only one of those contained appropriate absolute dates. I labeled the other responses as inappropriate for various reasons. For example, one participant left an event out of their timeline. Another participant described the "formation of the universe" and the "formation of the earth" as a simultaneous event. The remaining three were deemed inappropriate in terms of sequencing and dates because in all three instances the participants indicated that all events except the birth of Jesus Christ happened simultaneously between 3000 and 6000 years ago (Figure 10, 11, & 12). One participant even provided a day by day chronology for the events (Figure 12).

Figure 10. Creation Account - 4500 Year Old Earth
The pre-service language arts/social studies teachers provided three responses placed in Category 3. None were appropriate in terms of both sequencing and complete absolute dating. One response, however, was appropriate in terms of sequencing, while the remaining two were deemed inappropriate due to the absence of one or more events from the timeline.

Almost three-quarters, 73%, of the ministers that completed Item 13 gave an appropriate sequencing of events, with 20% of that three-quarters providing appropriate sequencing and appropriate relative/absolute dating of events. One minister pointed out a problem with the timeline item 13 (Appendix A). He/she asked
for a definition of the event "people". It was noted that this is a vague term, however, the ambiguity did not determine the sorting of any response. Consequently, I replaced the term "people" with "bipedal hominids" in the pre-service teacher version of the questionnaire (Appendix B). Of the pre-service science teachers that completed Item 12, 44% provided appropriate responses with 18% of that 44% assigning appropriate sequencing and appropriate relative/absolute dating of events. Similarly, roughly half, 57% of the seven pre-service language arts/social studies teachers provided appropriate responses with no one giving both appropriate sequencing and appropriate relative/absolute dating of events (Table 4).

Table 4. Summary of Event Timeline Scores for All Participants

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Evolution

The responses varied dramatically among the ministers concerning their understandings and beliefs about evolution. No participant explicitly described evolution as a change in gene frequency over time, rather explanations focused on "creation", hominid evolution, "change in living organisms", and justifications for their responses. For example, ministers described evolution as:

- *A theory of how the universe was created, the earth was created, and how life came to exist and evolve over time.*

- *True but not a generative (genesis) theory*

- *I think if we evolved from apes and monkeys, we would not still have apes and monkeys.*

- *A scientific theory which seeks to explain the development and diversity of organisms in the world*

The participants hold many levels of understanding regarding evolution. Very few expressed completely naïve or highly sophisticated views, as compared to those of scientists. Instead, almost all of the participants demonstrated moderately informed understandings of the scientific concepts. I characterized responses containing
partially appropriate understandings due to the presence of popular misconceptions as moderately informed.

Participants' acceptance of evolution ranged from one end of the spectrum to the other as well:

[I] *accept the Genesis account of creation.*

*I am open to it* [evolution]. *I just don't know very much about it. I do not think that evolution and the Biblical account of creation are at odds.*

*... it seems to be [a] true part of God's will.*

Most ministers accepted evolution as an explanation for their particular, moderately informed definition of the concept. Only 20% of the fifty-six participants who responded to item 18 (Appendix A) indicated that they considered evolutionary theory to be "lacking and unsatisfactory" and "difficult to reconcile with faith in a creating God". The rest viewed evolution, in one way or another, as "God's hand at work".

The pre-service science teachers demonstrated a wide range in understandings of biological evolution. One sophomore participant described evolution as:

*... the selective increase in genetic allele frequencies over time...*
Meanwhile, other seniors described it as:

[A] scientific theory about how the earth and life came to be.

Evolution is the belief that man came from monkeys.

Evolution is just a theory of how man was created.

The last quote came from a participant whose science concentration is Biology. Most definitions of evolution provided by those who concentrated in Biology consisted of short, somewhat vague statements like:

The change in a population over time.

Such statements were common among participants from a variety of science backgrounds, not just the biologists.

Acceptance of evolution theory as understood by the participants varied. Some participants embraced evolution as evidenced below:

I agree with evolution.

No conflict with my belief in God as Creator.
I think there is strong scientific evidence to support adaptation and that it is not necessarily contradictory to the Bible.

It [evolution] has been demonstrated in laboratory experiments and by examination of the fossil record.

Other participants conditionally accepted evolution. For example, responses included:

*I believe micro-evolution on a smaller scale exists...*

*I believe in a type of evolution - created and maintained by God. As He created the Earth and life on it, animals changed shape and form to fulfill His desires.*

*It is not how people came to be; but I believe in the evolution of some species.*

*I do agree some things evolve. I do not agree that man evolved from apes.*

*Evolution is the manner in which species have changed over time to function better in their environment. I think*
it is controlled by God, not genetics and feel God is perfectly capable of giving animals what they need to survive.

For those participants who conditionally accepted evolution, two conditions needed to be met: 1) God must remain an active force in process of evolution and 2) man could not descend from apes. Several of the pre-service science teachers indicated that they did not accept biological evolution as a valid explanation based upon their understandings of the concept. For instance, participants wrote:

Progression of adaptations and improvements in animals over time based on Natural Selection. I don't believe in Evolution.

Evolution attempts to explain how man came about. I think it is a theory and I think that no one should be forced to believe it.

Evolution explains how humans evolved from apes. I do not believe that evolution happened.

Evolution is the gradual change of something, like an organism, over time as it adapts to its environment. I
believe all things change over time, thus I believe in

evolution itself, however, I do not believe in the Theory of

Evolution.

I think that there are many, many holes in the

evolutionary theory that are not presented in public

schools. For example, irreducible complexity, the

probability, genetics doesn't work the way necessary for

evolution, no real evidence in the fossil record.

Most pre-service science teachers accepted evolution based on their own particular
understanding of the concept - an understanding that in most cases could be
characterized as moderately informed. Of the twenty-one participants that gave
responses indicating degree of acceptance of evolution, one-third stated they "don't
agree with it".

Only one of the pre-service language arts/social studies teachers provided a
response that could imply a full disagreement with evolution theory as evidenced by
his/her statement, "For mankind it doesn't exist. Darwin was wrong." It is just as
likely, however, that this statement represents a conditional acceptance of evolution.
The remaining six participants provided responses that indicated a moderately
informed understanding of biological evolution. Of those, two held conditional
acceptance of evolution based on beliefs about hominid evolution. They wrote:
I think there are some aspects about evolution that are true, but I don't believe we evolved from monkeys.

Evolution describes how things change over time. I don't believe humans evolved from monkeys, etc.

The other four participants provided both vague and detailed responses regarding evolution. The two vague responses included:

The change in things over time.

Evolution is change over time. I believe it happens.

The more detailed responses included:

Evolution is the theory that traits that increase survivability are passed on and those that are less desirable die out. I believe that it is a great theory.

[Evolution] is the modification of a species to be successful in their environment. Evolution occurs daily.

Selective breeding is part of evolution.
While only about half (49%) of the ministers responded that they experienced any formal science instruction in college beyond any general requirements, almost all (94%) considered their knowledge of science to be "good" or "very good". For most of the ministers this confidence in their knowledge of science is justified; for some it is misplaced. Although nearly three-quarters of the participants provided minimally appropriate responses regarding the historical sequencing of events, there remained about 20% of the participants who described their knowledge of science as "good" or "very good" who provided inappropriate responses for item 13. Only 8% of all assessable responses, or four inappropriate responses, showed evidence of creationist theories in their timelines. Three out of those four also explicitly indicated their failure to accept evolution theory in responding to the question about evolution in item 18. The responses addressing participants' understandings of evolution demonstrated that the overwhelming majority of participants are moderately informed about the topic and willing to accept evolution theory. Considering the extent of participants' prior exposure to formal science instruction, I was surprised by the fairly high percentage of participants who provided appropriate responses, including the three that provided appropriate dates for all events in item 13. Within the specific context of this study, the findings demonstrate the inaccuracy in the depiction of clergy as predominantly uninformed about scientific content.

The vast majority of pre-service teachers rated themselves much as the ministers did in terms of their own knowledge level of science. Almost all participants rated their knowledge level as "good" or "very good", including one-third of the pre-service science teachers who rated their knowledge level as "very good". None of the
pre-service science teachers rated their knowledge level as "poor" or "very poor", yet they achieved the lowest percentage of appropriate responses (44%) among the three groups represented in this study (ministers = 73% & pre-service language arts/social studies teachers = 57%). It is important to note, however, that 22% of all the ministers did not provide responses capable of being assessed for content understanding as opposed to only 7% of the pre-service science teachers. Appropriate response percentages do not reflect this discrepancy. The pre-service science teachers, however, achieved similar percentages of appropriate absolute dating on the event timeline with 18% as compared to the ministers 20%. The pre-service language arts/social studies teachers, considering the small number of participants, achieved similar percentages to those of the pre-service science teachers at 57% compared to 44% respectively. No pre-service language arts/social studies teacher, however, provided appropriate absolute dating. Considering the number of participants in each group, the number of responses capable of being assessed for content understanding, and the percentages of appropriate responses, as a group the ministers performed slightly better than the pre-service science teachers who performed slightly better than the pre-service language arts/social studies teachers. As compared to the four ministers (8%) who showed explicit evidence of creationist views, four pre-service science teachers (15%) and one pre-service language arts/social studies teacher (14%) provided responses containing evidence of young-Earth, creationist beliefs. Although three out of the four 'creationist' ministers explicitly stated they did not accept any form evolutionary theory, only two of the four 'creationist' pre-service science teachers indicated the same. The other two pre-service science teachers and the one pre-service
language arts/social studies teacher conditionally accepted aspects of evolution. The responses addressing pre-service teachers understandings of evolution showed that most of the participants are moderately informed about biological evolution and are willing to accept the concept in part or whole. In general, content understandings regarding geological history and evolution among all groups revealed little difference.

**Understandings of the Nature of Science**

Items 9, 10, 16/17, and 18/19 identified various ideas represented among all participants regarding specific aspects of the nature of science including, epistemological constructs, limitations of science, the nature and role of evidence, and the nature and role of theories and laws. Participants provided responses reflecting positivist and constructivist epistemologies when defining the term "science". For example, one minister revealing a more constructivist perspective defined science as:

*The pursuit to understand the physical universe through interpretation of physical evidence...*(Ref. - Thomas Kuhn).

Much more common, however, was the more positivist depiction of science as:

*Search for truth by observation.* [minister's response]
Science is a search for truth. It seeks to give definitive answers...[minister's response]

Search for empirical truth. [minister's response]

Empirical knowledge [minister's response]

An objective analysis of our surroundings and ourselves [pre-service science teacher's response]

Search for truth, how and why things happen [pre-service science teacher's response]

The examples sited above demonstrate the extreme ends of the epistemological spectrum represented in the data. The positivists views expressed were generally much more radical in nature than any constructivist views, although a gradation of both positions existed. Two of the seven pre-service language arts/ social studies teachers indicated uncertainty about a definition of science, for example:

The study of life, chemistry, biology and I don't know

The study of life? (not sure)
Both of these participants, however, used language including "concrete evidence" and "objective" in other questionnaire items in describing science indicating a positivist slant.

The span of participants' notions concerning the limitations of science shows as much variation as their epistemologies, although I found no apparent connection between the two. Some participants considered science capable of or attempting to provide "meaning" to life and answering the question of "why". For instance, these participants described science as:

A rational system to explain existence and life in all aspects. [minister's response]

The study of the universe to find answers for all of life's questions. [minister's response]

The task of integrating, while discovering, the world around us - explaining, not only to define, but to give meaning to life. [minister's response]

Attempting to understand God and our universe and world better. [minister's response]
The rational search for solid answers regarding questions of faith. [minister's response]

Science is the study of what, where, how, and often why. [minister's response]

The study of how and why the Nature around us functions. [pre-service science teacher's response]

Inquiry into why things are, how things are, and what things are… [pre-service science teacher's response]

The want to learn about life and why life works. [pre-service science teacher's response]

The study of how and why things are the way they are with a concentration on making life on earth better for its inhabitants. [pre-service language arts/social studies teacher's response]

Many others viewed science differently, limiting it in scope to include only "natural phenomena". These participants described science as:
The observation of natural things. [minister's response]

Study of the physical world. [minister's response]

Attempt to explain the natural universe. [minister's response]

Science is the study of the natural world. [minister's response]

The systematic explanation of how the universe works. [pre-service science teacher's response]

The study of our physical world - how things work. [pre-service science teacher's response]

Explanation for the things that happen in nature. [pre-service language arts/social studies teacher's response]

The items concerning the nature and role of scientific evidence revealed ideas about two specific aspects of the nature of science including: 1) various epistemological constructs and 2) the temporal nature of scientific evidence. As seen in earlier items, epistemologies ranged from radical empiricism to more constructivist
constructs, with most participants indicating a predilection towards a more positivist position. For example, participants holding to a positivist epistemology (a) defined scientific evidence and (b) described its role in science as:

(a) Provable. *Knowledge that has certainty.* (b) of *paramount importance.* [minister's response]

(a) *Events that are repeatable, can be reproduced* (b) *basis of scientific "law" or fact* [minister's response]

(a) *What is seen and measured is known* (b) *basis of science* [minister's response]

(a) *Scientific evidence is proof in the laboratory under controlled conditions.* (b) *Without evidence there would be only theories, no science, no proof.* [minister's response]

(a) *after studies, tests, experiments, data gathering, the outcomes show certain truths or results* (b) *this is the evolution of science, of our belief about how "creation" works...*[minister's response]
(a) facts and proofs gained by scientists (b) leads to
theories and laws [pre-service science teacher's response]

(a) Supports what you conclude and can be proven (b)
you need evidence for it to be true [pre-service science
teacher's response]

(a) Hard facts, indisputable (b) prove theories to make
them laws [pre-service science teacher's response]

(a) Concrete data or findings (b) Basis for laws and
theories [pre-service science teacher's response]

(a) Empirical proof of theories (b) The way that theories
become laws. [pre-service language arts/social studies
teacher's response]

(a) Concrete evidence (b) It determines what becomes
laws [pre-service language arts/social studies teacher's
response]
(a) Evidence that would be provable by anyone (b) basis for scientific fact [pre-service language arts/social studies teacher's response]

Participant responses representing more constructivist epistemologies wrote:

(a) Biased (b) much [minister's response]

(a) Attempt to explain something with so-called factual data (b) is the core [minister's response]

(a) Scientific evidence is what we are able to observe through our human senses and understanding about God's creation. (b) It helps us understand, in a very imperfect way, God's incredible creation. [minister's response]

(a) may be true today, not tomorrow - example atom (b) guide only [minister's response]

(a) reproducible data or even data not reproducible that follows other established laws, that support a theory (b)
important to compile, debate, springboard to new theories...crucial [pre-service science teacher's response]

(a) anything that supports a particular scientific theory
(b) evidence helps make a theory more believable [pre-service science teacher's response]

(a) Things that have been found to support a theory in science (b) It gives more strength to scientific theories.
[pre-service language arts/social studies teacher's response]

It is certainly possible that the first two 'constructivist' responses sited above represent an anti-science attitude rather than an epistemological construct. The last quote cited from a minister's remarks on the temporal nature of science served as the only response to explicitly address this aspect of the nature of science. Four pre-service science teachers provided the only other responses that possibly addressed the temporal nature of science. For example, one participant wrote about evidence:

(b) it supports theories but doesn't necessarily make them true
Responses from interviews yielded more detailed descriptions of pre-service teachers' conceptions of scientific evidence. For example, Student 1 discussed how scientific evidence supported his understandings of a 4500 year old Earth.

Student 1 -

*I couldn't give great scientific evidence for what I believe.*

*I mean a lot of this is brought up from what I believe based off the Bible and what I accept as true. I couldn't give specific contextual evidence. Like what I would see as simple, like in Genesis, it talks about the Flood and there's a lot of societies that have a flood story, and like my evidence for that is dating back to why I see Scripture as being true, is when we look around and see dinosaur fossils on tops of mountains and sand too. I look at that and I say that maybe the dinosaurs were washed out in the Flood and because of that sand is found on the tops of mountains.*

Researcher -

*Like what kind of fossils are you talking about?*

Student 1 -

*Like other fish fossils and that's scientific - that's kind of further validation to me that what I'm accepting - like a lot stems from the Scripture and the Bible and the*
Creation story and that is further validation that - like I don't have like carbon dating that can back up my beliefs or anything. I'm sure that if I had time to go look up a couple of things. I've kinda heard some things in the past that kinda help validate it, but I can't give like carbon dating that says that this is the way it is, you know.

Researcher -

Do you see the fossils, etc as scientific evidence?

Student 1 -

To scientists it would look foolish to them but I would say, yeah, for me, it would be scientific evidence that that story does hold true.

In the transcription above, Student 1 clearly describes scientific evidence as capable of supporting his faith-based understandings. He provides some examples, but implies that more scientific evidence is out there. Additionally, he perceives his understanding of scientific evidence to be different from that of scientists, yet at least as valuable in drawing scientific conclusions. Student 2 makes similar statements during the discussion of scientific evidence. For example:

Student 2 -

I'm not trying to say that there's scientific evidence in the Bible, but I do believe there's enough scientific evidence
to prove - but I wouldn't know enough about it, just kinda stuff I've heard. In your upbringing you have certain presuppositions or I come into any kind of scientific discussion with the presupposition that the earth was created in six literal days. So then, I guess what I'm trying to say is that I've never found any other evidence to prove otherwise.

Researcher -

How would you define scientific evidence?

Student 2 -

Indisputable facts that can be demonstrated clearly.

Student 2 also described scientific evidence as supporting his faith, but explicitly states that such evidence is not contained within the Bible. When asked for examples of scientific evidence, he talked about:

There's hard absolute scientific evidence like gravity - Newton's first and second laws of motion. Like stuff we know. That's like black and white areas as opposed to gray areas.

Student 3 describes science in terms more consistent with current philosophy of science during portions of the interview and in more naive terms during others.
Overall, however, this participant provides descriptions of the nature and roles of scientific evidence that are much more consistent with constructivist-based philosophies than the other interviewed participants. For example, she says:

Student 3 -

Now I think in science when you have a scientific theory you can test that theory and people can dispute that theory and you can develop a body of evidence to support that theory.

Researcher -

Can you prove that theory?

Student 3 -

There are very few theories that we can actually prove, I believe.

Researcher -

What's an example of a theory that we could prove?

Student 3 -

Maybe something in gravitational theory.... If there is a body of evidence that is strong enough, then the theory would become a law, but it's still not indisputable in my mind.... In this class that I was telling you about [philosophy of science course], we were talking about science and the origins of science and what constitutes
the origins of science and we tend to think of science now as being a lot of hard and fast facts and laws and things that do not change. And we're looking for patterns we're looking for a way to interpret the world around us that's predictable and so because of that we look for these relationships and try and establish laws. But from the very beginnings of science any theory that anyone would put forth was never considered indisputable. That was really what the essence of science was, was the fact that other of your colleagues could question that and challenge a particular theory or idea. So that's how I tend to view science that we have theories and we have laws that are supported by a great body of evidence but it's not necessarily proof.

Researcher -
You're sort of giving me two different things here. On the one hand you're saying that there are theories that can be proven and on the other that nothing's indisputable.

Student 3 -
Well, I don't know if there are things that can be proven. When you talk about gravitational laws it seems like you could kind of prove that. But I don't really know. You could drop two things in a vacuum at the same time and
the evidence supports that theory, whether it proves that
theory or that law in every situation I don't know.

Researcher -

If you had a theory or a law, what would you have to do
to prove that?

Student 3 -

I don't know. I don't know because to prove it would
mean that it would be indisputable and new perspectives,
like Einstein's theory, that was an entirely new way of
viewing some of the old evidence and it put a different
twist on it so it changed things.

Interestingly, both Students 2 and 3 had taken a post-secondary course focused on the
nature of science during the past year. It was not the same course, however. As such,
there is no way to account for instructional or content differences between the two
courses in terms of participant responses. Student 4 served as the only pre-service
language arts/social studies teacher to participate in the interviews. When asked to
provide a definition of scientific evidence she provided the following response:

Student 4 -

It's what proves a theory true or false. Some of the things
that could be scientific evidence are like DNA tests or
archeological finds or something that you find that says to
the best of my knowledge this theory is true beyond a shadow of a doubt....

Researcher -

So at what point does evidence prove something beyond a shadow of a doubt?

Student 4 -

When it becomes a law. That's what I learned in science.

When you have enough evidence that it proves your theory beyond a shadow of a doubt, then the theory becomes a law.

Student 4 provides a familiar description of scientific evidence as being capable of delivering proof "beyond a shadow of a doubt" if in sufficient quantity. The implications of failure to appreciate the limitations of scientific evidence make construction of a complete and appropriate understanding of scientific theories and laws virtually impossible. Student 4 illustrates this point in her discussion of evolution below:

I am not sure at this stage in my life that I'm sure that man descended from apes. I'm not sure that I actually agree with that. I haven't heard any conclusive proof.

There are lots of theories, but I haven't heard any conclusive proof that that actually happened.
I used two multiple-choice items, items 9 and 10, to examine all participants' understandings of the nature and roles of theories and laws. Almost half or more of the participants selected the appropriate response for each question in both items, except for two (Figure 13a-b, 14a-b, and 15a-b). Only 29% (two participants) of the pre-service language arts/social studies teachers gave the most appropriate response for Item #10b, however, the small sample size must be considered. Had just one more participant selected the most appropriate response, then almost half of the group as a whole would have chosen the most appropriate response.

Figure 13a. Ministers' NOS Responses to Item #9
Figure 13b. Ministers' NOS Responses to Item #10
Figure 14a. Pre-service Teachers' NOS Responses to Item #9

Figure 14b. Pre-service Teachers' NOS Responses to Item #10
Figure 15a. Pre-service Language Arts/Social Studies Teachers' NOS Responses to Item #9

% of NOS Response of True (T) or False (F) - Appropriate Response Circled

Figure 15b.  Pre-service Language Arts/Social Studies Teachers' NOS Responses to Item #10

The second question in Item 9 essentially asked whether theories become laws over time. Three-quarters or more of the participants from each group believed that theories become laws over time (Figure 16).
As evidenced by responses to items asking for descriptions of science and scientific evidence, the participants predominantly held positivist epistemologies. Some of these participants gave responses that revealed their understandings of the nature of science to include the purpose and, more surprisingly, the capacity of science to yield absolute truth. As indicated during one of the interviews, pre-service teachers may view scientific evidence as capable of supporting alternative ways of knowing as well. Accompanying this view may be the perception that although their views of scientific evidence differ from most scientists, what they consider as evidence is just as valid as the evidence of scientists. Most participants, however, held views of a science precluding 'why' explanations and limited to physical phenomena, yet maintained notions consistent with extreme positivism. For example, one minister
who defined science as, "... the study of the natural world" described scientific evidence as "proof in the laboratory under controlled conditions. Without evidence there would be only theories, no science, no proof". Naïve notions of the relationship between evidence and theories/laws in science also occurred regularly. For instance, many participants espoused the idea that evidence in sufficient quantity can prove a theory, thus elevating it to the status of law.

The difficulty in assessing the affects of the misunderstandings of the nature and roles of theories and laws is due to the pervasiveness of the belief that theories evolve into laws over time (see Fig. 16). The ubiquitousness of these misunderstandings made it impossible to identify relationships with any particular participant characteristic across or within groups. I experienced further difficulty in establishing relationships due to the disconnected nature of the participants' understandings regarding various aspects of the nature of science. For example, while many of the participants scored well on the items regarding the nature and roles of theories and laws and provided responses that reflected informed understandings of science and scientific evidence, not one participant consistently demonstrated an appropriate understanding of all the aspects of the nature of science assessed in the instrument. For instance, of all the participants, two pre-service science teachers provided the most appropriate responses for all components of Items 9 and 10. Both participants, however, made statements in other items that show an incomplete and/or inappropriate understanding of other aspects of the nature of science. For example, one of the two participants defined science as the:
Neither of these participants accepted evolutionary theory as they understood the concept. In fact, one participant described creation of the universe as occurring over a six day period in their event timeline in Item 12 (Appendix B). While I make no claim that the responses to Items 9 and 10 show complete and appropriate understandings of the nature and roles of scientific theories and laws in these two participants, their responses show at minimum informed understandings.

The Relationship between Science and Faith

Existence and Nature

Items 6, 7 (minister survey only), 8, 14/13, 15/14, 16/15, and 20/19 (Appendix A/B) addressed participants' ideas about the relationship between science and faith and the implications of their understandings of that relationship on their faith and the faith of others. Of the sixty ministers who responded to Item 14, all but one acknowledged a relationship between science and faith (Fig. 17). In contrast, roughly 15% of each of the groups of pre-service teachers failed to acknowledge any relationship, with an additional 15% of pre-service language arts/social studies teachers providing an alternative response.
Figure 17. Responses to Item #13 - Do you see a relationship between science and faith?

The minister that provided the "no" response in Item 14 did not choose to explain that particular response, yet in another item he/she wrote, "science and religion answer different questions". Similarly, the one pre-service teacher that explained their "no" response wrote, "not really, different domains". The one alternative response provided by a pre-service language arts/social studies teacher explicitly indicated uncertainty as evidenced by his/her statement, "I am not sure".

The other 98% of the ministers, 85% of the pre-service teachers, and 71% of the pre-service language arts/social studies teachers explained their "yes" responses in ways characterized by the following categories: 1) science is a way to learn more about God's creation, 2) science provides physical evidence related to faith, 3) science
is a gift from God, 4) science and faith answer two separate questions, 5) science and faith inform one another, 6) conditional congruence between science and faith, and 7) faith is inherent in science. Table 5 provides examples of responses that illustrate participants' ideas concerning the relationship between science and faith.

Table 5. Categorization of Participants' Ideas about the Relationship between Science and Faith

<table>
<thead>
<tr>
<th>Category</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Science is trying to understand what God has put in place, whether all scientists are Christians or not. [minister]</td>
</tr>
<tr>
<td></td>
<td>Science offers an opportunity to understand God's creation more fully. [minister]</td>
</tr>
<tr>
<td></td>
<td>Science, at its best, is a process of learning more about God and ourselves through the study of God's creation. [minister]</td>
</tr>
<tr>
<td></td>
<td>Science is the way to explain the methods of God's actions [pre-service science teacher]</td>
</tr>
<tr>
<td></td>
<td>Science seeks to explain various aspects of my Faith that have to do with the natural world [pre-service science teacher]</td>
</tr>
<tr>
<td></td>
<td>Yes, everything in our world was created by God. Science is studying our world. [pre-service language arts/social studies teacher]</td>
</tr>
<tr>
<td></td>
<td>Carbon dating for Bible material, times/dates... [minister]</td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>The more science learns, the more proof for God and Biblical truth. [minister]</td>
</tr>
<tr>
<td></td>
<td>Archeology has played a significant role in helping Biblical scholars understand history and application. [minister]</td>
</tr>
<tr>
<td></td>
<td>Science can support creation theories. [minister]</td>
</tr>
<tr>
<td></td>
<td>...As with Moses and the Red Sea - yes God did do that and there may be a way He did it that can be explained by science.... [pre-service science teacher]</td>
</tr>
<tr>
<td>3</td>
<td>God is creator of worlds, Prime Mover, and is giver of all wisdom and knowledge. [minister]</td>
</tr>
<tr>
<td></td>
<td>Scientific knowledge is another tool/gift God has given. [minister]</td>
</tr>
<tr>
<td></td>
<td>Yes - God created &quot;science&quot; (see definition #16) [definition #16 states science is] the study and knowledge of almost anything (humans, earth, animals, astronomy, geology, etc) [pre-service science teacher]</td>
</tr>
<tr>
<td></td>
<td>As I said earlier, God the Father placed everything on this earth and gave us the intellect to find scientific theories and laws. [pre-service language arts/social studies teacher]</td>
</tr>
<tr>
<td>4</td>
<td>Both sources of knowledge and understanding, sometimes compatible, sometimes not - two different types of knowledge. [minister]</td>
</tr>
<tr>
<td></td>
<td>Science deals with natural... phenomena, but faith deals with beliefs of the heart, often unseen with the eyes. [minister]</td>
</tr>
<tr>
<td></td>
<td>Science explains. Faith also explains but gives reasons. [minister]</td>
</tr>
<tr>
<td></td>
<td>Science describes 'what' and 'how'. Faith is concerned with 'why'. [minister]</td>
</tr>
</tbody>
</table>
Table 5. (Continued)

<table>
<thead>
<tr>
<th></th>
<th>Statements</th>
</tr>
</thead>
</table>
| 5 | Science tells me 'how' - it informs my faith. Faith tells me who did the creation. [minister]  
Yes, they inform each other. Faith explains the meaning and the 'seat' of power. Science describes the universe. [minister]  
While they address two entirely separate fields of reality (one measurable, one not) they can intersect. There you'll see science confirm the Bible's claims. If science doesn't confirm initially, it will later reverse position and confirm. [minister]  
Both inform each other with different aspects of reality. [minister]  
Science explains what we take on faith. [pre-service language arts/social studies teacher] |
| 6 | They agree but faith (Bible) is more reliable. [minister] |
| 7 | Science begins with assumptions about reality - faith is essential for both [minister]  
It requires faith to believe a lot of scientific theories (electrons, quarks, evolution) for which we have no solid proof. [pre-service science teacher]  
You need to believe that the theories are true and therefore have faith in them. It's a different kind of faith though. [pre-service science teacher]  
Science requires faith, if you don't believe in what you are doing you probably won't do it. [pre-service language arts/social studies teacher] |

Over half of all participants in each group responded "yes" to item 15/14, which asked if they thought there were any contradictions between science and religion (Fig. 18). The pre-service science teachers constituted the highest percentage of "yes" responses at 69% as compared with the pre-service language arts/social studies teachers and ministers at 57% and 53% respectively. Most participants listed events or concepts
they thought constituted a contradiction, including: "healings beyond the capability of medical science", "cloning", "creation and evolution", "age of Earth…", "Noah and the flood", and "Big Bang". Additionally, several ideas emerged regarding the contradictory nature of science and religion. In many cases, different participants described similar ideas but circled different responses (i.e. "yes" or "no"). This is due to differences in participants answering the questions from the perspective of their personal convictions and ideas in certain cases and from their assumptions and understandings of the personal convictions and ideas of others. Some participants

![Figure 18. Perceived Contradictory Nature of the Relationship between Science and Faith](image-url)
focused on the literal interpretation and inerrancy of the Bible as the source of tension.

For example, two ministers wrote in response to item 15:

*Yes, only if you read the Old Testament literally, which I choose not to do.*

*No, the Bible is not a history book...*

Two pre-service science teachers also provided responses that reflect this idea as evidenced by their statements:

*Yes, surely there will be times when scientific findings seem to contradict religious beliefs, however humans make mistakes - God is perfect so I would believe a religious explanation over a scientific one.*

*No, for example, many Christians believe in the inerrancy of the Bible. However there are many statements in the Bible that have been shown to be incorrect based on the assessment of evidence.*

*Yes, I do think science and religion both try to explain existence, when I believe there is only one TRUTH.*
Others, because of their views on the nature of the relationship between science and faith as pertaining to different domains, gave the following responses:

_No, I think they can be integrated._ [minister]

_No, there shouldn't be because they pertain to different aspects of reality._ [minister]

,Yes, God's ways are not our ways. _Not to be flippant, but the Resurrection cannot be explained scientifically._ [minister]

I interpret the implied contradiction in the last response to be when scientific attempts are made to explain issues of faith, in effect, two "...different aspects of reality."

According to one minister, the contradictory relationship between science and faith can be ascribed to "'science' seek[ing] to become a religion and when science claims absolute truth". He/she placed the blame for any contradiction squarely on the radical empiricist, while excusing religion altogether. Another minister considered science and religion equally responsible for irreconcilable differences and wrote, "When science makes overreaching claims and when religion does the same, contradiction results". One pre-service language arts/social studies teacher articulated
this notion as well in the statement, "They both [science and religion] desire to be the only gods of this world."

One minister did not circle "yes" or "no", but rather wrote this, "There are apparent contradictions, for example the origin of life, but I think those can be reconciled by a deeper understanding of both science and faith". Several other participants echoed the idea that inadequate understanding and the failure to recognize that inadequacy produces contradictions, for example:

No, only misunderstandings from either side getting too arrogant about their viewpoint. [minister]

Yes, because our knowledge of both God and science are imperfect, we are not yet able to see how the two fit perfectly together. [minister]

If there appear to be contradictions then it is our not yet being able to fully understand the world and universe as it really works yet. For example, the stretching of the universe may be caused by many things and may make it appear to be billions of years old, but there are other explanations that also fit. [pre-service science teacher]
Role of Evidence in Faith

I was surprised to find that the overwhelming majority of the participants considered evidence to be used in faith (Fig. 19). However, with the range in understandings of scientific evidence demonstrated in item 19/18, the vernacular use of the term 'evidence', and the variety of epistemologies represented by the participants, I was not surprised that the qualitative responses revealed considerable variation in the nature of evidence used in faith. Descriptions of that evidence spanned physical and metaphysical domains. For example, participants viewing the role of evidence in faith to hold a more metaphysical nature wrote:

*Our human senses and understanding also help us explain our experiences of God. But through the power of God's Holy Spirit, we also have spiritual senses and understanding that take us beyond the evidence of our human senses and understanding to a deeper, more intimate, understanding of God. Still, our understanding of God is very imperfect.* [minister]

*When people pray long enough, spiritual enlightenment often occurs.* [minister]
These two ministers describe evidence used in faith as a metaphysical "enlightenment" imbued by God. Others considered evidence used in faith to be physical artifacts or observable events. These participants described their views as follows:

*Archeology continually confirms much of Hebrew scriptures...* [minister]

*Faith healing and other miracles*  [minister]
Faith is "the evidence of things not seen". God's answers to prayers give evidence of God's reality and God's caring for humankind. [minister]

... in Old Testament archeology... [minister]

Faith is supported by rational evidence, but is not limited to it. For example, evidence can be collected regarding answered prayer, but the evidence is not the sole basis for belief. [minister]

The Holy Land, its still there and many people go there for religious reasons. It's not an artificial place. People are constantly looking for Holy relics from Biblical time, the Ten Commandments, the ark, the ark of the convenient, etc. People often look for tangible fragments of a time long passed to support their faith. I am not saying this is correct to do, but it is done. [pre-service science teacher]

Scientific evidence is used to prove if an object really existed in a certain time or place that it is said to have existed in a religion, such as fossils of plants specific to
Jerusalem around 33AD found on the Shroud of Turin, thought to be a burial cloth of Jesus Christ. [pre-service science teacher]

Artifacts found that are mentioned in the Bible... [pre-service science teacher]

Yes, the cactus cloak of Our Lady of Guadalupe, the shroud of Turin, and the many miracles produced by not only Jesus Christ, but by the many disciples he left on this earth to lead us. [pre-service language arts/social studies teacher]

The finding of Noah's ark, evidence of flood, discovery of Dead Sea scrolls. [pre-service language arts/social studies teacher]

Some participants stated "creation" to be the evidence they used in faith, as one minister put it, "the wonder of creation gives evidence to a creator God". Additionally, two pre-service science teachers shared similar thoughts.

God Himself said that all of creation cries out that there is a God. And as we make more discoveries this is true.
There must have been a designer of what we see. It could not happen by accident.

...There is evidence for existence of God for example. In my opinion creation and the earth is one example.

Other participants gave responses that centered on written historical accounts, for example:

*History* [minister]

*Holy Scriptures* [minister]

*Bible* [minister]

... reality of the life of Christ, reality of the death of Christ, reality of the lack of a dead body of Christ, the historical Biblical account [minister]

*The empty tomb, the witness of these who have seen* [minister]

*In church they always quote the Bible as an example of evidence we are right.* [pre-service science teacher]
There are several other documents that support stories in the Old Testament. [pre-service science teacher]

Bible stories = evidence of God/Jesus [pre-service science teacher]

I view the rise of the monotheistic religions which occurred at the same time (roughly) in world history as being an objective fact or evidence that one God is responsible for the existence of our universe. [pre-service science teacher]

The Bible is enough evidence. Things in the Bible are coming true today. [pre-service language arts/social studies teacher]

Bible. [pre-service language arts/social studies teacher]

Books of faith are often used as evidence. [pre-service language arts/social studies teacher]

Personal experiences also appeared in responses among participants. They wrote:
Personal experience - Perception is reality [minister]

Testimonies: "What God has done for me..."... [minister]

... evidence of the value of love - changed lives; evidence of the value of forgiveness - changed lives [minister]

Faith adds to the realm of scientific evidence the evidence of personal experience with the divine. [minister]

Changed lives through a relationship with Jesus. [minister]

If one is speaking of scientific evidence, no. A changed heart or a new perspective is not necessarily quantifiable. Our evidence for faith is subjective. [minister]

One of the interesting things about one's faith walk is that a scientific approach cannot be used. Anyone who learns the rules of math can prove 1 + 1 = 2. People of faith experience God individually which cannot be given to another as an equation. [minister]
... It is certainly strengthened by the evidence of experience. [minister]

...experiential - I have seen evidence of Christ's action in my life and the life of the Church. [minister]

Each person notices evidence of their relationship with God in their own life. It is not found in experiments or planned observations, but rather through the learning process as you explore your faith. [pre-service science teacher]

Works evidence faith [pre-service science teacher]

I believe this is a personal experience for whomever is involved... [pre-service science teacher]

Of the eight participants that responded "no", six were ministers and the other two were pre-service science teachers. The primary reason given involved the nature of faith. For instance, two ministers wrote, "in my opinion, faith does not require evidence - or it is not faith" and "if there is evidence, it is not faith". One of the pre-
service science teachers explained his/her response by the following: *Faith is not about evidence, it is about your belief.*

Several pre-service teachers provided general comments on the nature of evidence as used in faith rather than citing specific examples of that evidence. For example, they wrote:

*There are all kinds of evidence. Some people use personal experiences. At my church there is a couple that is greatly involved in the Shroud of Turin. But I think there is a difference between evidence in science and evidence in faith.* [science]

*Yes, but not just the same as science.* [science]

*Yes, but it's not scientific; it's spiritual.* [science]

*Yes, but don't think many people of faith are knowledgeable enough to use evidence to back their faith.*

[language arts/social studies]

Pre-service teachers again provided further insight into the nature and role of evidence during the course of interviews. Participants described more than just scientific evidence, they also discussed how they viewed the relationships between different
types of evidence as used in faith. For example, Student 1 provided the following responses:

Researcher -

*Are the types of evidence [used in faith] different?*

Student 1 -

*Yeah I would say so.*

Researcher -

*So what's the difference?*

Student 1 -

*Initially some evidence is shown to initially take that step in faith but I think it's like taking action upon that faith and like through that seeing the results....that's my personal experience. I don't know if that's like that for every person.*

Research -

*Ok so that was the evidence then, it wasn't physical evidence that sparked your faith?*

Student 1 -

*No probably not, I can't think. I can give you an example of physical evidence that helped further my understandings and beliefs of the faith that I had. I guess I've talked to people about the Shroud of Turin. Have you*
heard about that? I guess it's the cloth that they
supposedly wrapped Christ in when He was in the tomb.
They said that there was like bloodstains found I guess
where His hands were laid across His chest maybe and on
His feet. And there were bloodstains on and they said like
also that the imprint that it left like because I guess when
He was resurrected that like a light shown out and like
burned or seared the cloth or whatever. And they said
that they took a computer and scanned the image of what
was burned in there and the face, the image that was left
in there, like resembled paintings and pictures that have
been made of Christ.

Researcher -

So do you see that then as being scientific evidence?

Student 1 -

Yeah, to me that's scientific evidence.

Student 1 identified various types of evidence used in his faith including experiential
and physical evidence. He even described the physical evidence as "scientific",
although later in the interview he expressed uncertainty as to whether it constituted
true scientific evidence from the perspective of a scientist. He also discussed the value
of personal experience as a form of evidence used in faith.
I believe that personal experience is stronger than some theory that's packed up in a book. Real life! I think that most people would believe that too, that they would believe their personal experience before they would believe something packed up into a book no matter how many pages of evidence is presented before.

For Student 1, experiential evidence outweighs all other types of evidence. Student 2 echoes this notion of the value of personal experiences. He provides an example that he reveals is an event that he experienced himself. He said:

Student 2 -

Like a person that has cancer and you go in a week later and they're healed.

Researcher -

Do you know any personally like that?

Student 2 -

Yes. Yes!...It was a friend of my family. The doctors have no explanations. In my mind I have no doubt that God made it happen.

Whereas Student 2 emphasizes experiential evidence, Student 3 focuses almost solely on physical evidence as used in her faith. For example, she said:
There's also other evidence. In the Catholic Church tradition you have evidence of, you have actual physical artifacts of people who taught, who preached, who whatever, from way back when and in the Church these physical artifacts have been retained. You have like the Shroud of Turin you know that has been examined many times. That's a physical artifact and it can be - it was interesting to me because I grew up Baptist and so these physical artifacts to me were - I didn't know how to interpret those at the beginning whether I wanted to swallow this hook, line, and sinker or whether I wanted to investigate a little bit more about, well, what are the credentials. So somebody said this, so now I base my whole faith it or is there some more evidence for it. I did study some of the scientific studies that were done for example on the Shroud of Turin. Some people seem to be more willing to base their faith on feelings and others want to base their faith on a little more investigation.... It's [evidence used in faith] different in some ways because scientific evidence, if you set up something to test a theory, it should be replicable. Some of these experiences we have in faith are not replicable, but it's
still evidence because, I don't know, let me think about that for a minute. Scientific evidence is usually replicable. If you're talking about the origins of the universe we can't duplicate that but we can study different aspects of it and conjecture back. So there we're still talking in the intangible as far as being able to duplicate that exactly. Scientific evidence is usually more quantifiable. You can duplicate it. Ok that's how they're different but both of them are the same in that they are both pointing us in the direction of truth. So I think what we are trying to do in science is determine the truth of natural laws, of how things work, of the origins of things and the evidence points us towards the truth but whether we can ever say, 'I have all the truth', is something else altogether.

Student 3 makes several important statements. First, she views physical evidence as an important type of evidence that informs her faith. Secondly, she sees scientific evidence and evidence used in faith as similar and different in several ways. Later in the interview, however, she indicates that she believes scientific evidence to be the stronger of the two types.
The nature of human beings to politicize things or whatever, I tend to think that scientific evidence is stronger. I don't think that rules out the other by any means. Scientific evidence is more objective because when you test a piece of bone or DNA testing you will get a result. A quantifiable result that's not affected by what you want it to turn out to be or what you want it to be.

Then you have to reconcile this objective data with your theory.

Student 4 discusses the limitations of scientific evidence and emphasizes the value of personal experiences.

Researcher -

Do you think there are other types of evidence besides scientific?

Student 4 -

Yes, I think sometimes you have to believe things on faith. Sometimes you see things or hear things that really can't be explained by scientific means but that doesn't make them any less true.
Student 4 also talked about the use of historical evidence in constructing her faith-based understandings. She described such historical evidence as consisting of various writings, which prompted the following question:

Researcher -

*Is there any difference then between historical and scientific evidence?*

Student 4 -

*I think there's a slight difference because in scientific evidence of a civilization you would dig it up and you do the carbon dating and you date the paint on a piece of pottery or you could do a scientific composition to find out what the paint is made out of. But when you say historical evidence, you can use writings and other documentations that you find.*

Researcher -

*Ok and that wouldn't be scientific?*

Student 4 -

*No, because it's subjective.*

Researcher -

*Ok and science is always objective?*

Student 4 -

*Yes, should be.*
Researcher -

*Should be?*

Student 4 -

*It's not always, no, because people make it subjective when they put their own spin on the evidence.*

Researcher -

*When would it be objective, an example of when a person doesn't put their spin on evidence?*

Student 4 -

*I don't know.*

Student 4 made use of historical, physical, and experiential evidence in her understandings of faith. It remains unclear, however, how she decides which evidence to use if two or more are in apparent conflict. Furthermore, she explicitly states her incomplete understanding of at least one type of evidence, scientific.

**Accessibility for All**

Items 6 and 7 (minister survey only) dealt with participants' views regarding the ability of an individual to live as a Christian while practicing science (Appendix A/B). All of the participants but one pre-service language arts/social studies teacher indicated in every item that "yes" a Christian can practice science and remain faithful and, in the case of ministers, scientists can be Christians. The participant who
provided the "no" response explained their choice as follows, "A lot of scientific content revolves around finding scientific answers to support findings, instead of allowing things to be because God made them that way."

The purpose of item 7 (ministers only) was an attempt to tease out the view of scientists as 'secularists'. None of the ministers appeared to hold a separatist view of scientists. Instead they provided responses like, "why not?", "most definitely", "of course", "I have 2 in my congregation", "absolutely!", and "as long as they profess Christ as Lord and Savior, believe in the Resurrection, and acknowledge God as the Creator of the world and universe". The last statement is consistent with the United Methodist Church's doctrine of what it means to be a Christian, so although the response is conditional the participant constructed it in the most inclusive way possible to him/her.

Role of Science in Affecting Religious Views

Of the fifty-five ministers that responded, a little more than three-quarters (76%) wrote that their knowledge level of science did affect their religious views in the following ways:

- **Science, in some ways, confirms my views on God.**
- **Affirms importance of faith, not everything can be based on "scientific knowledge".**
The more I understand the amazing intricacy of Creation, the more I appreciate the Creation.

It keeps my religious views from being arrogant, from trying to explain too much.

I could not be "fundamentalist", as I was as a child.

Supports it.

I wish I knew more about science. What I do know gives me an incredible sense of awe for the One who created all this that we study through science.

Roughly three-quarters (72%) of the pre-service science teachers that responded (n=25) also indicated that their knowledge level of science affected their religious views. Of that 72%, two-thirds described science positively impacting their faith (e.g. "strengthening" their faith). Participants expressed a variety of other views as well, for example:

It furthers/strengthens my convictions in Christianity.
I question why things are the way they are, that is my personality. The more I learn about science the closer I feel to God and the stronger my faith. I hope to always learn more about science and grow in my religious views.

I believe in evolution and Jesus Christ. I believe that my science background has helped me obtain a better understanding of religion.

Yes, knowing what I know about sciences, I tend to question religion more than most would like for me to.

The more I know about science (and its limitations) the more I believe in a greater Being

I believe there are certain things (like the formation of Earth and the evolution of life) that I will never understand while on Earth (either from a scientific or religious view).

In contrast, however, only three of the pre-service language arts/social studies teachers (43%) considered their knowledge level of science to have any influence on
their religious views. One provided a similar response to those of the majority of the pre-service science teachers as cited below:

_Science just confirms what the Bible states._

The other two participants indicated they felt deficient in their scientific understandings.

_I don't know enough about science._

_I am not familiar with science as much as religion._

Almost a quarter of the ministers (24%) and pre-service science teachers (28%) and over half of the pre-service language arts/social studies teachers (57%) did not think that their knowledge of science affected their religious views. The only reasons given, with one notable exception, revolved around the notion that "science and religion answer different questions". That exception involved the introduction of the idea that religious views inform one's knowledge of science, as illustrated by the minister's response, "It's the other way around".
Importance of Scientific Literacy

All but two ministers and every pre-service language arts/social studies teacher that responded to item 8 indicated that they believed it to be important for a Christian/person of faith to be scientifically literate. In contrast, only 77% of the pre-service science teachers (n=26) acknowledged the importance of scientific literacy for people of faith. In addition, a disproportionate number of participants in grade sixteen or higher provided the "no" responses for Item #8. While these participants only constitute 58% of the total number of pre-service science teachers, they accounted for 83% of the negative responses. The explanations for the "no" responses included:

*All Christians in the early years after Jesus' resurrection did not have our understanding of basic, modern science.*

[minister]

*[Faith is] All you need to even worry about.*  [pre-service science teacher]

*My faith is totally separate from what I understand scientifically.*  [pre-service science teacher]

I interpret the first statement to follow the argument of the second, that the only things that are really important are spiritual ones. Others who qualified their "yes" responses
further articulated this idea with statements like the following, "though scientific literacy is not necessary for being a faithful Christian". Most participants, however, explained their "yes" responses in ways represented by the following quotes:

In a technical/scientific society, understanding what science can and cannot do is important. [minister]

I think it's important for everyone to be scientifically literate to some degree. [minister]

It informs faith to expose some inaccurate faith assumptions and scientific assumptions. [minister]

It helps one make ethical decisions... [minister]

It helps to understand God more fully. [minister]

Someone who has little scientific knowledge may believe science and religion are two separate spheres, but in reality they can overlap. [pre-service science teacher]

I think that if people had a better understanding of science and how it worked then there would not be as
much controversy over which is true science or religion.

[pre-service science teacher]

It is especially important when relating to people and understanding God, how he created the world and how marvelous his creations truly are. [pre-service science teacher]

I believe they are two separate but essential realms. [pre-service science teacher]

I believe that it's important that everyone be scientifically literate because to make good decisions in our world involves understanding many scientific facts and principles. [pre-service science teacher]

The more knowledge any person has, then the better off that person will be. [pre-service science teacher]

I've had some friends whose faith has suffered b/c they were convinced that evolution was true. [pre-service language arts/social studies teacher]
We live in an information age where people don't always rely on faith. It's important to stay aware of new findings whether you agree or disagree with them. [pre-service language arts/social studies teacher]

How can you argue for or against something you know nothing about? [pre-service language arts/social studies teacher]

The Bible explains creation not photosynthesis, electricity, etc. [pre-service language arts/social studies teacher]

To be objective and knowledgeable. [pre-service language arts/social studies teacher]

In items inquiring about participants' ideas of the relationship between science and religion, at least half of each group viewed the two as contradictory. The points of contention they listed unfortunately contained many science concepts found in most states' curriculums. One of the primary reasons that participants gave for the contradictions was an individual's lack of understanding of both science and religion's appropriateness in answering a given question (i.e. 'how' and 'why'). Among these participants a pattern emerged concerning the relationship between identifying
contradictions between science and religion, the belief that science answers questions of 'why', and thinking theories become laws over time. 'Why' is often used in scientific explanations as seen in the title of the classic science book series, How and Why Wonder Books. A problem exists because 'why' can imply purpose, whereas 'how' only implies process. Most Christians consider the Bible to contain descriptions of God's purpose for humanity, nature, etc. When science, as wielded by some radical empiricists, attempts to claim understanding of 'why', it appears as though science is claiming an authoritative understanding of purpose. If the 'why' of scientists conflicts with the 'why' of God, then a logical, irreconcilable contradiction occurs. Such a logical impasse, born of a view of science that is capable of more than what most philosophers of science think possible, can permeate many aspects of an individuals' understanding of science. For example, one participant that indicated contradictions exist between science and religion, defined science as "a religion" and when asked "what is evolution and what do you think about it" responded, "I try not to!"

Misunderstandings of theories and laws combined with positivist views may potentially play a more subtle role that would lead to conflict regarding any theory perceived as making claims contrary to their religious beliefs. For example, for some of the participants various elements of evolution theory conflicted with beliefs of the 'creation account'. If these participants misunderstand the nature of theories and laws and conform to the positivist notions that there exists objective truth and that truth can be realized through scientific processes, which many indicated they did, they may be led to believe that scientific law is viewed as the pinnacle of knowledge. Whether the participant can divorce one 'way of knowing' from the other or not, the idea that a
concept that offers an alternative to or conflicts with their religious beliefs could potentially 'earn' the 'lofty' stature of a scientific law creates the threatening atmosphere of competition. Undoubtedly, uninformed science students who hold Christian beliefs could unnecessarily experience these same feelings of tension between science and religion.

Another interesting finding included the prevalence of the idea that evidence is used in faith. Almost all the participants indicated that evidence is used in faith, but different groups described the evidence differently. The evidence described in item 20/19 was categorized after removing all the questionnaires that could not be assessed because 1) the item was left blank, 2) the participant gave a "no" response, or 3) the response was too general to assess (Appendix A/B). I created three categories: 1) historical, 2) experiential, and 3) physical. Of the responses that could be assessed for type of evidence, 100% of the pre-service language arts/social studies teachers (n=5) described the evidence used in faith as being of a historical nature (e.g. Bible, Dead Sea Scrolls, etc.). Almost two-thirds (60%) of the ministers (n=35) included personal experiences as evidence (e.g. changed lives). When evidence identified as personal experiences and historical were combined, the two together constituted 83% of the responses. Lastly, 44% of the pre-service science teachers (n=19) described the evidence as being of a physical nature (e.g. artifacts, creation, etc). Additionally, when both physical evidence and historical evidence were combined, the two together constituted 78% of the responses. Such results suggest each group viewed evidence differently with the ministers predominantly focused on experiential evidence, the pre-service science teachers focused on physical and historical evidence almost evenly,
and the pre-service language arts/social studies teachers focused exclusively on historical. It is unclear whether differences are due to group association, understandings regarding faith, or other factors.

A few participants explicitly stated that they understood scientific evidence and evidence used in faith to be different. Only one pre-service science teacher, however, elaborated on that difference in a coherent, although vague, way.

_It [evidence used in faith] is not found in experiments or planned observations, but rather through the learning process as you explore your faith._

Other participants described evidence used in faith to be of a scientific nature. In those cases, the participants' positivists views regarding science remained as their use of scientific evidence moved from one way of knowing to another. For example, one pre-service science teacher wrote:

_Scientific evidence is used to prove if an object really existed in a certain time or place that it is said to have existed in a religion, such as fossils of plants specific to Jerusalem around 33AD found on the Shroud of Turin, thought to be a burial cloth of Jesus Christ._
One positivist participant, however, demonstrated a more appropriate understanding of the nature of evidence in the context of faith than in science. For example, the participant described scientific evidence as "what is seen and measured is known" and in describing evidence as used in faith wrote, "Scriptural witness - Bible stories are used as evidence in faith - difference is it's possible to have differences of opinion about evidence". This ministers' ideas about the nature of evidence being open to a variety of interpretations more closely matches all but the radical empiricist's view of this aspect of the nature of science.

Virtually all participants felt that both Christians and scientists had equal access to the others' domain. In addition, most participants considered science to affect their religious views in positive, supportive ways. Almost all the participants viewed scientific literacy, defined on the instrument as "a basic understanding of how science works", as important, because it teaches people what questions "science can and cannot" answer, "helps in ethical" decision making, and impacts their faith and understanding of God. As such, most participants viewed scientific literacy as providing an appropriate understanding of the nature of science and assisting in the understanding of the "role of science in society and personal life" (National Research Council, 1996, p.21). Disturbingly, however, this was not the case for several participants, most of whom were pre-service science teachers. Unfortunately, one possible reason for the bulk of "no" responses emanating from the group with the most experience with formal science education may have its roots in the common teaching of 'school science'. 'School science' is typically described as the portrayal in the
classroom of science as a static body of hard facts. Such notions easily identified in one participant's response on a different item on the questionnaire:

Science is just facts. You don't have to believe that science is absolute truth. You can still hold religious beliefs.

Ministers' and Pre-service Teachers' Role(s) in Shaping Others' Views of the Relationship between Science and Faith

Items 11/7 and 12/11 deal with the degree to which ministers serve in shaping members of their congregations' scientific understandings. Almost three-quarters of the participants (72%) reported addressing scientific issues with church members. Examples of topics covered by the participants included, "human behavior", "astronomy", "cause and effect in sexual preference", "genetics, abortion, hybrids, food industry", "computers, global warming", "most medically related", "Big Bang", "cloning, end of life issues", "origin of universe, ethics of science", "stem cell research", and "evolution vs creationism and theistic friendly aspects of quantum physics". One participant stated that he/she "addresses any questions raised". Only about one-third of pre-service science teachers (35%, n=26) and pre-service language arts/social studies teachers (29%, n=7) indicated that any scientific issues were addressed in their place of worship. Those pre-service teachers cited similar topics as the ones described above by the ministers as issues being addressed.
Additionally I inquired about whether their audience thought about science in the same way they did. Almost half (51%) of the ministers replied that their congregation did. Five pre-service science teachers (19%) and one pre-service language arts/social studies teacher (14%) indicated that they believed their students thought about science and religion in the same way they did. One of the more prevalent trends included implications from ministers that they hold better understandings of science than their congregations, unless their congregation consists of scientists, in which case their understandings were equivalent. For example, participants wrote:

Yes, I have many Christian scientists in my church.

No, often they confuse the two.

No, less informed, less reflective, they don't see much connection between them.

No, I've always had a deep interest in science, which is not shared to the same degree by most of my congregation.
No, I don't know. Ours is a small rural community.

Science is low on the list of important issues. In that way,
at least, I see a difference.

In a similar trend, ministers considered their views of the relationship between science and religion to be more progressive, more liberal than their congregations' views. For example, participants described the discrepancy in views as follows:

No, It's [the congregation is] more conservative and against evolution.

No, my congregation is highly educated but theologically more conservative than I am, and some are more suspicious of scientific insights.

No, they [the congregation] are more conservative, and I think they probably view science with more suspicion and see it as often in disagreement with religion.

Lastly, one minister summed up the crux of the issue for science educators by stating:

No, school age members conflicted about dualism - 2 'truths'.
The pre-service teachers that believed that their students will think about science and religion the same way they do explained themselves below:

Yes, in the Bible belt [science]

Yes, however, I don't think this is a topic that teachers should cover in high school. I think that this is something students have to decide for themselves. [science]

Yes, to a certain degree, I feel that most people separate the two and have ideas or beliefs in common. [science]

Yes, teachers have an incredible amount of influence on their students. [language arts/social studies]

While the remainder the pre-service teachers responded "no" to item #11, many provided comments and explanations that revealed an array of assumptions and generalizations about their students. For example, they wrote:

No, they are not as educated. [science]
No, because our society and public schools lead children to believe that theories without evidence are true and religion is all myth. [science]

No, most students that are ‘religious’ do not try to conceive the ideas of evolution. Most students that are in-depth in scientific knowledge do not have a strong faith. I think it would be rare to have students that had a strong belief in both areas. [science]

No, probably not because most science teachers teach evolution as fact and say nothing about creationism. [language arts/social studies]

No, students in middle school tend to see things more black and white so they would be either one or the other. [language arts/social studies]

No, they mostly accept what textbooks say. Their understanding of religion is very minimal. Most do believe there is a God or higher being. [language arts/social studies]
Such assumptions and generalizations are just as inappropriate and potentially damaging as believing everyone thinks as they do. Fortunately some pre-service teachers acknowledged that "there will be a very broad spectrum" of beliefs.

Most ministers were concerned about their congregations' understandings of scientific concepts and views of the relationship between science and faith, as evidenced by the high percentage of those who address these issues with church members. Participants reported addressing scientifically complex topics (e.g. genetics, global warming, astronomy, stem cell research, quantum physics, etc.) in which they perceived they possessed "good" to "very good" levels of knowledge (Fig. 5). They shared their knowledge with congregation members using incomplete understandings of the nature of science. This probably impacts the views of the congregation members concerning the relationship between science and faith as half of the ministers reported their congregations maintained similar views. The other half of the participants considered their understandings to be more informed and liberal, and specifically identified "school age members" as conflicted about the relationship. Similarly, all of the pre-service teachers participating in this study provided evidence of inappropriate understandings of one or more aspects of the nature of science. Instruction derived from such understandings almost ensures a proliferation of misinformation and affects students' views of the relationship between science and faith.
Role of Seminary/Divinity School and Higher Education

All sixty-three ministers responded regarding the role seminary/divinity school played in changing their views of science. Over 87% indicated that seminary/divinity school did not change their view of science. One-third of the ministers responded to the open-ended portion of the item yielding three different reasons for the participants' "no" responses. One participant indicated that his/her views did not change:

...because my divinity school training did not delve deeply into the doctrine of creation.

Another participant suggested that science and religion are two different things, for example:

Science see facts, religion deals with mystery and faith.

Other participants simply described having already formed their views of science before ever entering seminary/divinity school, for instance:

I had formed my basic views in college.

I've always seen God's hand at work in scientific matters.
My faith already informed my understanding of science.

I have been a Christian believer all my life and I approached science differently than most scientists. My views of creation were strengthened in seminary.

It is important to note that in all three types of reasons listed above, participants indicated they had already developed a view of science that did not change during seminary/divinity school. Although, the first participant cited appears to have been open to changing his/her beliefs had more instruction been devoted to the topic. Of the participants who did experience change, one indicated that while he/she experienced a "little" change, his/her views were changed "mostly in college". Other reasons for change included:

* Tried to see theological implications.

* More appreciation for science and faith and their relationship to each other

* Not addressed in seminary, but learned to think critically
  - more open minded.
Most participants formed their views of science before entering seminary/divinity school and then maintained those views until the present. As previously mentioned, those views are predominantly positivist, with a couple of notable exceptions. In contrast, one-third of the pre-service science teachers (n=27) and 43% of the language arts/social studies teachers (n=7) indicated their views changed as a result of attending university courses. Those changes for the most part appear to be positive:

Yes, I learned to enjoy science more as I began the higher science classes and I found that science could be applied to all aspects of my life. [science]

Yes - I learned that some ideas in public school weren't presented in the best way. I learned in college that science changes more than I previously thought. [science]

Yes, in grade school science is taught in terms of 'definites'. In college it is taught as a 'questioning' and 'exploring' subject. [science]

Yes, I learned that like most social sciences that science itself is often up for debate/reexamination. [language arts/social studies]
Yes, Biology 105 made me wish I had taken more interest in Math and Science because the content and information covered was interesting. [language arts/social studies]

For these students, post-secondary instruction assisted them in constructing more appropriate understandings of and interest in science. The majority of students, however, reported that they experienced no change in their view of science as a result of attending university courses. They provided the following comments:

*No, I learned a lot more about science, but none of my views really changed.* [science]

*No, my depth of knowledge about science has definitely changed, but my perspective, views, and relationship to my faith/beliefs have not.* [science]

While post-secondary instruction changed some pre-service teachers views of science, the majority kept the same views they constructed before entering the university. These views were almost exclusively positivist in nature.
Chapter Five

Conclusions and Implications

Some individual responses provided by participants involved in this study illustrated sophisticated and appropriate understandings of various aspects of the nature of science and scientific content related to earth history and biological evolution. Furthermore, many of those participants applied their understandings in insightful ways to inform their conceptualization of the relationship between science and faith. Just as importantly, however, many recognized a need exists for better understandings of science and its relationship to faith for them, their colleagues, their students and their congregations. As science teachers and science teacher educators, we should take the initiative to provide instruction concerning science and its relationships to other ways of knowing, rather than placing the burden solely on the clergy and others outside of the science education community. As such, implications exist for science teacher education and development of partnerships with clergy.

Science Teacher Education

Almost every participant involved in this study described their level of knowledge of science as either "good" or "very good" regardless of educational background. Additionally, almost every participant provided responses that evidenced incomplete and/or inappropriate understandings of one or both of the controversial concepts assessed in the questionnaires. The similarity that exists among the groups in
terms of both perceived and actual scientific content understandings indicates that, in many instances, post-secondary instruction fails to produce science teachers that are more informed than other college graduates regarding geologic history and biological evolution.

A wide array of possible reasons exists for the lack of difference between pre-service science teacher understandings and the understandings of others. The identification of those reasons lie beyond the scope of this study, but whatever the reason, students enter their teacher education program in need of further content knowledge construction. As science teacher educators, we must make the decision of whether to meet this need ourselves or hope that others will meet it. In making this decision, the question of "what knowledge is of most worth" is raised due to time restraints teacher educators face and the enormous amount of education content to be taught. Due to the central nature of the concepts of geologic time to the earth sciences and evolution to biology, however, it is hardly arguable that these concepts represent one of, if not the, most important concept to their respective disciplines. As such, failure to address a lack of understanding of the key concepts of a discipline that pre-service teachers may very well teach regardless of their concentration constitutes a failure in assisting students in the construction of pedagogical-content knowledge.

Addressing critical content knowledge needs while facilitating the construction of essential pedagogical knowledge in the timeframe available to most teacher educators represents a considerable challenge. A possible means of accomplishing this goal, however, involves teaching pedagogy in the context of the content. For example, when providing instruction regarding cooperative learning, the teacher could first
model such pedagogy with the pre-service teachers and use biological evolution as the content during the modeling. In such an environment, students have the opportunity to construct appropriate understandings of both scientific content and pedagogy. As the students practice using their newly constructed pedagogical knowledge in a clinical environment, the teacher educator can assess both the students' understandings of the pedagogy and the content by analyzing the appropriate use of each during the assignment. Understanding the content, however, is only one step in developing a more informed view of the relationship between science and faith, albeit an essential one. As one participant put it, "How can you argue for or against something you know nothing about".

Additionally, an appropriate understanding of the nature of science becomes critically necessary. An understanding of scientific content without an appropriate understanding of the processes and tenets used by the community that accepts that content as valid results in the undesirable outcome of the uniqueness of science being lost. For almost all participants, the aspects of science that make it unique from other ways of knowing were either entirely absent from their understanding of the nature of science or were distorted by their naïve vision of the domain as a whole. For such individuals, the inability to distinguish elements of scientific ways of knowing from other ways of knowing may impact the relationship they see between science and faith, particularly when those elements are common in one form or another in both domains. For example, based upon the questionnaire responses and interview data, evidence serves as an example of a concept common to both scientific and faith-based ways of knowing. As a result, it becomes important that pre-service science teachers
are able to distinguish between scientific and other types of evidence. Otherwise they may view any type of evidence as equally valuable and acceptable in developing scientific assertions. For instance, some participants described scientific evidence to be as inclusive as "anything that supports a scientific theory" making the lines defining scientific evidence blur as one type of evidence becomes virtually the same as another. Such a conceptualization of scientific evidence opens the possibility for other types of evidence (i.e. historical) to impact supposed scientifically drawn conclusions and conversely gives scientific evidence the capacity of supporting/proving faith-based assertions. For example, several participants described a number of scientific techniques and processes employed to analyze the Shroud of Turin for age, physical composition, etc. and used those findings to support the faith-based conclusion that Jesus Christ is the Son of God. In this and many other instances, participants apparently fail to understand or realize the reasons that scientific evidence is not capable of supporting the assertion that Jesus Christ is the Son of God. As such, their incomplete and inappropriate understandings of scientific evidence and the nature of science directly impacts both their scientific and faith-based understandings.

Participants noted other similarities as they saw them between science and faith, many of which are based on a naïve understanding of the nature of science. A few participants made the point that some view "faith" as an integral component of both science and religion. This idea was represented on two different levels. One minister appropriately referred to the inability of science to provide empirical evidence for some of its founding suppositions, while other participants made note that some make no distinction between science and faith because they do not know what makes
them different. For some the question becomes, "why should they?" They may experience science and religion the same way - sitting, listening to an authority figure dispense 'truth'. As several participants described it, the issue exists as one of credibility. Without an appropriate understanding of the nature of science, the origins of scientific knowledge become as, if not more mysterious than those of faith-based understandings. For example participants commented on evidence used in faith (i.e. personal experience) as being more "real" than evidence used in science:

I believe that personal experience is stronger than some
theory that's packed up in a book. Real life! I think that
most people would believe that too, that they would
believe their personal experience before they would
believe something packed up into a book no matter how
many pages of evidence is presented before.

Such ideas highlight the importance of engaging students in the processes of science in order to provide them experiences they can compare and contrast to processes involved in their other ways of knowing. We must accurately represent science as real and unique. Coupling the science experiences with direct instruction concerning elements of the nature of science provides students the opportunities to build rationales, which allow for reasoned distinctions to be made between ways of knowing. If such reform is not achieved, the misrepresentation of science will
continue to infect future generations of science teachers and clergy, spreading the
disease of 'school science'.

The data collected regarding the role of seminary/divinity school in changing
participants' views of science reveals a trend that constitutes a serious indictment
against the science education community. While various sources contribute to
constructing scientific understandings, in terms of scientific concepts and the nature of
science, science educators claim the goal, and consequently the responsibility, of
providing appropriate, meaningful, and effective instruction resulting in scientific
literacy. So, when almost 90% of the participants state that seminary/divinity school
did not change their views of science, whatever understandings they express, at least
in part, reflect what messages 'school science' conveyed. As the data concerning the
understandings of scientific concepts and the nature of science show, in general,
ministers are moderately informed of some scientific concepts, while up to 80% show
little understanding of specific aspects of the nature of science. Such findings echo
what we already know, empiricist-based 'school science' delivers on transmitting facts,
but fails miserably when it comes to assisting students in constructing meaningful and
appropriate understandings of the nature of science (Driver et al., 1996). Additionally,
almost one quarter of the pre-service science teachers indicated that they do not think
it is important for a person of faith to be scientifically literate. This percentage was
the highest among all groups. While further inquiry is necessary to determine the
reasons behind these participants' responses, it is interesting to note that the group with
the highest percentage of "no" responses for Item #8 is the group with the most
experience with 'school science' (Appendix B).
In an attempt to make science a more meaningful endeavor for students, research-based reform efforts suggest the use of instructional strategies that actively engage students in authentic scientific process, as well as, the use of direct instruction regarding the nature of science (McComas, 2001b). In terms of teacher education, one method of reaching this goal includes the implementation of practitioner research. By engaging pre-service science teachers in research on their own practice, they gain exposure to scientific process in an environment of consistent reflection and systematic analysis concerning their teaching. When facilitating practitioner research, care must be taken to scaffold instruction such that the teacher educator can provide explicit instruction regarding the elements of the nature of science most observable at any given time. In addition, because most pre-service science teachers have never experienced any authentic scientific inquiry, the scaffolding process becomes that much more important to the students' learning and successful completion of the research project.

Lastly, the need exists for the design and implementation of curriculum to assist pre-service and in-service science teachers in developing instructional strategies for their students. We need instruction that, while remaining sensitive to students’ developmental levels, encourages them to reflect upon their understandings of the relationships between various ways of knowing and analyze alternative views of those relationships. In addition, helping students identify the science pieces of varying views that are consistent with current understandings of the nature of science may assist in: 1) the reduction of anti-science attitudes, 2) providing better understandings of the
limitations of science, 3) lead to valuing different perspectives, and 4) developing and exercising critical thinking.

Partnerships

The vast majority of participants indicated they saw a relationship between science and faith and most characterized that relationship as contradictory in nature. Many, however, qualified that characterization in other questionnaire items and during interviews by stating that better understandings of both science and faith could serve as an effective means of alleviating what they saw as tension between the two domains. Furthermore, participants from every group indicated they would like to have received formal instruction regarding the relationship between science and faith, yet neither the pre-ordained ministers nor the pre-service science teachers as a group gained more informed understandings of the relationship between science and faith in a formal context.

One potential benefit of addressing the relationship of science and faith in the classroom is exposure to diverse perspectives and ideas. Awareness of alternative perspectives serves as a critical characteristic for those who serve diverse populations. Considering the range in scientific and faith-based understandings found in all groups in this study, it is clear that diversity in terms of views of the relationship between science and faith is present at some level among almost any two people. Participants illuminated a consequence of not addressing the relationship of science and faith in the classroom when almost half of the ministers and some of the pre-service teachers
believed that their congregation/students thought as they did about the topic. Such generalizations and assumptions may be effectively addressed through an open dialogue with members of the clergy and scientific community who hold informed views. This type of intervention allows for the presentation of alternative perspectives while maintaining the control of informed views.

The ministers in this study indicated they valued scientific literacy and considered it capable of affecting other ways of knowing, a position held by many science teacher educators. So, it may be possible that we found in the United Methodist Church a companion in the struggle for a more informed public concerning science and its relationships to other ways of knowing. Yet, most of the participants experienced little to no instruction in seminary/divinity school regarding the nature of science and its relationship to Christianity or any other way of knowing. Curriculum developed to assist pre-service teachers and students in this area of science education should be considered for inclusion in coursework for perspective United Methodist ministers. Additionally, religious education materials designed for use with either ministers or laity possess the potential to serve as an effective means of building these important understandings as well.

Recommendations for Future Research

One of the important limitations of this study involves the small sample sizes of the pre-service teacher groups. While the usefulness of the pre-service language arts/social studies teachers was evident in gauging pre-service science teachers'
understandings relative to other populations, larger samples would provide researchers with more confidence. Additionally, when questioning participants concerning their understandings and attitudes toward evidence and controversial content, a potentially powerful question is, "What evidence would it take to convince you that the scientific explanation is appropriate" (personal communication with Dr. Keith Shepard on May 27th, 2003). Responses to this question provide information regarding both understanding of the concept of evidence and view of the relationship between science and faith. Lastly, research questions addressed in this study need to be applied to other denominations of Christianity and other religions. Insights gained from these other contexts allows for comparisons that may assist science teacher educators in better understanding the ways people view the complex interactions between science and faith.
Appendix A

Beliefs of the Clergy Regarding the Relationship Between Science and Faith
North Carolina State University

Instructions: There are no right or wrong answers to any of the following questions. Do not put any identifying information anywhere on the form. Total anonymity is of utmost importance. If you need more room than is provided in the answer spaces, please feel free to attach additional sheets. Thank you for your participation with this important study.

1. Age: 20-39, 40-49, 50-59, 60-69, 70-100+

2. How many years have you been a UMC Pastor? 0-3, 4-9, 10-19, 20-30, 30-40+

3. Did you take any science courses beyond your general college science requirements? Yes No If yes, how many semester courses beyond required? 

4. How would you rate your knowledge of science? very poor, poor, good, very good

5. Did your view of science change as a result of attending Seminary/Divinity School? Yes No Comments/Explanation:

6. Do you believe a Christian can be a scientist and remain faithful? Yes No Comments/Explanation:

7. Do you believe a scientist can be a Christian? Yes No Comments/Explanation:

8. Is it important for a Christian to be scientifically literate (that is, have a basic understanding of how science works)? Yes No Comments/Explanation:

9. Please mark true or false (T or F) to indicate your beliefs:
   a. ______ Scientific theories are often not very reliable.
   b. ______ If a theory holds up over time, it may become a scientific law.
   c. ______ Most scientists relate their research to existing theories.

10. For the statements below, choose A, B, or C for the response closest to what you believe. (A = theory; B = law; C = both)
    a. ______ An explanation for a natural phenomenon
    b. ______ Most often related to physics
    c. ______ Can usually be expressed mathematically
    d. ______ Supported by evidence
    e. ______ Useful in predicting

11. Do you address current scientific issues with church members? Yes No If so, give examples:

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12. In general, do you think that your congregation thinks about science and religion in the same way you do? Yes No Comments/Explanation:

13. Please place the following with approximate dates (if possible) on the timeline below: dinosaurs, formation of the Earth, people, birth of Jesus Christ, formation of the universe, first appearance of bacteria on Earth

14. Do you see a relationship between science and faith? Yes No If yes, explain:

15. Do you think there any contradictions between science and religion? Yes No If yes, give examples:

16. How does your knowledge level of science affect your religious views?

17. How would you define science?

18. What is evolution and what do you think about it?

19. a. How would you define scientific evidence?

   b. What role does it play in science?

20. Is evidence used in faith? Yes No If yes, give examples:
Appendix B

7. Are scientific issues addressed in your place of worship? Yes No N/A
If yes, give examples and state whether the scientific content is explained in the same way as in science courses you may have taken:

8. Is it important for a person of faith to be scientifically literate (that is, have a basic understanding of how science works)? Yes No Comments/Explanation:

9. Please mark true or false (T or F) to indicate your beliefs:
   a. ______ Scientific theories are often not very reliable.
   b. ______ If a theory holds up over time, it may become a scientific law.
   c. ______ Most scientists relate their research to existing theories.

10. For the statements below, choose A, B, or C for the response closest to what you believe. (A = theory; B = law; C = both)
    a. ______ An explanation for a natural phenomenon
    b. ______ Most often related to physics
    c. ______ Can usually be expressed mathematically
    d. ______ Supported by evidence
    e. ______ Useful in predicting

Beliefs of Pre-Service Teachers Regarding the Relationship Between Science and Faith
North Carolina State University

Instructions: There are no right or wrong answers to any of the following questions. If you need more room than is provided in the answer spaces, please feel free to attach additional sheets. Thank you for your participation with this important study.

1. Tracking Number:

2. Are you a science or history/social studies education major? Science Ed. History/Social Studies Ed.
What is your area of concentration?

3. How would you rate your knowledge of science? very poor, poor, good, very good

4. Did your view of science change as a result of attending university courses? Yes No
Comments/Explanation:

5. Would you consider yourself to be a person of faith? Yes No
Comments/Explanation:

6. Do you believe a person of faith can be a scientist and remain faithful? Yes No
Comments/Explanation:
11. In general, do you think that your students will think about science and religion in the same way you do?  
   Yes  No  Comments/Explanation:

12. Please place the following with approximate dates (if possible) on the timeline below: dinosaurs, formation of the Earth, first appearance of bipedal hominids (people), formation of the universe, first appearance of bacteria on Earth

13. Do you see a relationship between science and faith?  Yes  No  If yes, explain:

14. Do you think there any contradictions between science and religion?  Yes  No  
   If yes, give examples:

15. How does your knowledge level of science affect your religious views?

16. How would you define science?

17. What is evolution and what do you think about it?

18. a. How would you define scientific evidence?

   b. What role does it play in science?

19. Is evidence used in faith?  Yes  No  If yes, give examples:
Appendix C

Pre-Service Teacher Interview Protocol

1. Ask the participant to make a list using a pen and paper of what they consider to be scientific evidence for their answer to Questionnaire Item #12 - "Please place the following with approximate dates (if possible) on the timeline below: dinosaurs, formation of the Earth, first appearance of bipedal hominids (people), formation of the universe, first appearance of bacteria on Earth".

2. Ask the participant to make a list using a pen and paper of what they consider to be scientific evidence for their answer to Questionnaire Item #17 - "What is evolution and what do you think about it?"

3. Ask the participant to compare the lists of evidence they wrote for Questionnaire Item #12, Questionnaire Item #17, and his/her response to Questionnaire Item #19 - "Is evidence used in faith? Yes No If yes, give examples.". What similarities and/or differences are there regarding the evidence in Questionnaire #12, #17, and #19?

4. What do you view the nature and role of scientific evidence to be?

5. How is the nature and role of evidence different in different contexts (e.g. in science vs in history)?

6. How do you view your understanding of scientific evidence impacting your faith?


