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A Historical Analysis of the Relationship of Faith and Science and its Significance within Education

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Abstract

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John G. Yegge

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Dissertation Submitted in Partial Fulfillment

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Abstract

Science curriculum and pedagogy are at the center of a centuries-long debate concerning the appropriate relationship of faith and science. The difficulties that science educators face seem to be based in misinformation about the historical roots of this conflict. To address that conflict, the goals of this research were to separate myth from reality and to provide a necessary context to the current tensions that are disrupting science pedagogy and curriculum content within American public schools. Working within a theoretical framework of historical literacy, this qualitative, historical analysis was a comprehensive examination of the relationship of faith and science from ancient times through the Renascence to the emergence and development of Darwinism. The historical approach methodology was utilized as a means to document the systematic examination of past events, in order to illuminate and interpret the meaning of those events. The historical record revealed that science and religion are not necessarily incompatible and that the early Christian religion provided a fertile environment in which modern science could emerge. Also noted were many instances where the record was inconsistent with what educators have commonly taught as historical fact. Finally, the complex sources of tension between modern fundamentalist Christianity and Darwinism, which has appeared as a flashpoint in public discourse within science education, were examined in depth. Based on this analysis, the study includes recommendations for educators in their approach to addressing these challenges and teaching science. This analysis can produce positive social change for educators and their students, as this information is advanced as a means to enhance historical literacy among educators and their students.

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Acknowledgments

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Chapter 1: Introduction to the Study

In 2014, the field of education is precariously positioned amidst the continuing public debate over the proper relationship of faith and science (National Center for Science Education [NCSE], 2012). A noteworthy example concerns the ongoing legal proceedings within state legislatures and United States courts over whether or not intelligent design should be taught alongside evolution in public schools (Ecklund & Park, 2009). The continuing legal battle over science curriculum content negatively impacts the field of education, and the conflict ultimately reaches to the level of the classroom. Science teachers are regularly confronted with serious challenges as they try to teach amidst the ongoing conflict. Some public school districts are forbidden to teach the theory of evolution, others forbidden to teach creationism or intelligent design, and still others are required to teach both (Larson, 2003). Moreover, students find themselves at the center of the issue, wherein they may be exposed to modern science content during school hours and then contrasting notions about science at home, in church, or in the public sphere. This dissertation was intended to provide historical context and background to the debate, which will hopefully help diminish what has developed into a cultural clash.

Examples abound that underscore how deeply the continuing debate over the relationship of science and faith has permeated Western culture. For example, the Creation Museum in Kentucky contains elaborate displays, such as a full-size replica of Noah's Ark and models of life-size dinosaurs to illustrate the point proposed by the museum curators that dinosaurs were on the Ark. Another display explains how the

Grand Canyon was formed in just a few days during the flood (Hopkins, 2007). Conversely, authors of a popular evangelical website used by numerous ministers and their followers described the creationist's scientific position and purported that the dinosaurs perished because Noah did not get them on the Ark (Answers in Genesis, 2012). Curators of the American Museum of Natural History (AMNH; n.d.), which has a section detailing a version of human evolution, proposed a contrasting view of human origins. They proposed human evolution began 6 to 7 million years ago in Africa, wherein the first members of the human family spent most of their time in trees alongside their close primate relatives, millions of years after the dinosaurs became extinct (AMNH, n.d.).

Notwithstanding the claims of modern science, the widespread acceptance of the creationist worldview was demonstrated in a 2006 Gallup poll (Hopkins, 2007), which indicated that almost half of Americans believed that humans were created by God in their present form within the last 10,000 years. The propositions that the age of the universe can be measured in thousands, as opposed to billions of years, and that no evolutionary processes took place in the development of life are emblematic of creationist beliefs (Answers in Genesis, 2012). This type of biblical literalism is in sharp contrast to commonly accepted scientific findings that have been established and independently corroborated within several scientific disciplines. Executive director of the National Center for Science Education, Dr. Eugenie Scott, commented on the conflict, as it relates to education, "Teachers don't deserve a student coming into class saying 'Gee Mrs.

Brown, I went to this fancy museum and it said you're teaching me a lie'" (Hopkins, 2007).

A brisk, very public debate over the proper relationship of faith and science began following the Protestant Reformation and quickly spread through Europe during the Age of Enlightenment (Ecklund & Park, 2009; Stark, 2003). It gained renewed momentum in the late 19th century (Draper, 1874; White, 1896) and has continued in 2014 within academia and in the popular media (Dawkins, 2006; Harris, 2004; Schaefer, 2011). In the United States, the long-standing dispute has resulted in a century-long clash between strict creationists and Darwinists over public school science content, wherein the focal point is the theory of evolution (Larson, 2003). Such a highly charged conflict should be no surprise because fundamentalist Christian theology itself originated in direct response to the initial widespread acceptance of Darwin's theory, which included the idea that God played no role in the origins of life (Ferngren, 2002; Stark, 2003).

The polarization of the issue in relation to faith versus science seems to reach no limits. Although fundamentalist evangelical Christians have filed the vast majority of lawsuits related to science curriculum in public schools, hyperbole is not restricted to the creationist point of view. For example, the atheistic Darwinist Richard Dawkins (as cited in Stark, 2003) wrote, "It is absolutely safe to say that, if you meet somebody who claims not to believe in evolution, that person is ignorant, stupid, or insane" (p. 177). However, Dawkins's attitude is not new and reflects an atheistic ideology initiated by Darwin himself and embraced by his earliest supporters. Darwin once wrote that he could not understand how anyone could even hope that Christianity were true because the idea of damnation itself is so repulsive. Darwin's earliest advocate, Thomas Henry Huxley, commonly referred to as *Darwin's Bulldog*, clearly and repeatedly expressed his open hostility toward religion: "My screed was meant as a protest against Theology and Parsondom…the natural enemies of Science…if I have a wish to live thirty years, it is to see the foot of Science on the necks of her enemies" (p. 186). Huxley (as cited in Royal, 2006) also famously stated the following:

> Extinguished theologians lie about the cradle of every science as the strangled snakes beside that of Hercules; and history records that whenever science and orthodoxy have been fairly opposed, the latter has been forced to retire from the list, bleeding and crushed if not annihilated, scotched, if not slain. (p. 231)

Public education is at the epicenter of this debate, and both sides see the stakes as high—the minds and souls of their children. Some curriculum content specialists have reacted to the fierce conflict by representing one side against the other in science textbooks—either incorporating creationism or Darwinism within the curricula (David & Kenyon, 1993; Larson, 2003). Moreover, in some instances local school boards and even state governments have prohibited the teaching of creationism and, in other cases, forbidden the teaching of evolution in public schools. Other school boards have required that both creationism and evolution be taught alongside one another in the classroom. Given the discourse thus far, the issue appears irreconcilable and continues as a major source of contention in various school districts, states legislatures, and within the United States court system (NCSE, 2012).

A key obstacle to a viable solution seems to exist in the operational definitions used in the debate (Stark, 2003). Simply put, not all theists are creationists and not all evolutionists are atheistic Darwinists. Nonetheless, creationists are very willing to define any evolutionist or anyone who believes that an unfolding of the universe transpired over a long period of time, as an atheistic Darwinist. Conversely, ideological Darwinists are very content to portray anyone who rejects Darwinism in favor of a creator as a strict creationist (p. 177).

In significant contrast to atheistic Darwinism, many advocates of evolution have argued that God created through an evolutionary process (Hess & Allen, 2008; Jaki, 1990; Stark, 2003). For example, the Vatican hosted a conference on evolutionary theory in 2009 to coincide with the 150th anniversary of the publication of Darwin's *On the Origin of Species*. The Vatican cultural affairs officer, Gianfranco Ravasi (as cited in Pew Research Center, 2008), explained the Vatican's position: "There is absolutely no incompatibility between evolutionary theory and the Bible's message" (para. 1). Significantly, advocates of creationism and intelligent design were not invited to participate in the conference, as "organizers of the five-day conference at the Pontifical Gregorian University said Thursday that they barred intelligent design proponents because they wanted an intellectually rigorous conference on science" (Pew Research Center, 2009, para. 1).

Restricting the debate and the consequent science curricula that are produced in response to the debate to strict creationism versus atheistic Darwinism has both failed to resolve the problem and failed to acknowledge the reality that neither side seems able to provide a viable solution. An inherent, seemingly irreconcilable conflict does exist between "scientific atheism" and religion, which is continually exemplified in the science curriculum debate (Stark, 2003). A solution to the conflict may possibly be found by broadening the scope of possibilities and through a more clear understanding of the actual historical relationship of faith and science.

Ultimately, the objective is that students learn science in their science classes, not a religious or philosophical ideology.

A typical student's world is comprised of several largely independent but interrelating cultural groups. Three of the most prominent cultural groups for many students are family, school, and their faith tradition (Scheitle, 2011; Zimmerman, 2002). By its very nature, education often challenges students' beliefs, values, and perceptions—even deeply held convictions. Students can genuinely benefit by being challenged to improve their understanding of their perceptions, beliefs, and convictions. Intellectual challenges often serve not only to broaden the student's outlook, but to help sharpen his or her insights. Yet, the currently perceived conflict between faith and science has now morphed into a century-long battle between two distinct groups – strict creationists and Darwinists – and the narrow nature of the debate itself fails to answer the fundamental question concerning the actual relationship of faith and science. Moreover, the debate has become stagnant because neither side seems to tolerate dissenting opinions from their own in relation to this topic (Dawkins, 2006; Harris, 2004; Stark, 2003).

The dispute has continued in local school districts, state legislatures, the United States courts, and in the popular media, and the ongoing clash has directly affected students (Larson, 2003; NCSE, 2012). Students of faith could find themselves in the midst of a sharp contrast between their family's values and their educational experience. I intended this current research to provide a rigorous examination of the events surrounding the development of science as a discipline to assist educators and others as they grapple with understanding the tenable relationship of faith and science. My hope was that a full accounting of the important historical events and figures leading up to the Scientific Revolution of the 16th and 17th centuries would demonstrate that the scientific enterprise reaches well beyond the current creationist–Darwinist clash. Essentially, the history of the scientific enterprise is much broader and more interesting than the currently accepted narrative has indicated, and this study of the issue may provide frequently overlooked but important information for all interested parties. The various issues surrounding the debate in public schools at the time of this research concerning the historical relationship of science and religion will be addressed in Chapter 2 in greater detail.

Background

A cursory look at the history of religion and science reveals the depth of the problem. Historical accounts have been filled with misinformation that only served to exacerbate the tensions between the contending groups (Stark, 2003; Wiker, 2011; Woods, 2005). The intention here is to provide a realistic account of the key events that precipitated the development of science to provide clarity to what has become a bewildering and confused debate.

Regrettably, difficulties surrounding acceptable science curriculum and pedagogy have not been limited solely to the creationist versus Darwinist issue. In the West, a long-standing public debate concerning the proper relationship between faith and science finds its roots in the 18th-century phenomenon known as the Age of Enlightenment (Schaefer, 2011; Stark, 2003). The conflict theory, which purports that faith and science are diametrically opposed concepts, has become the commonly accepted narrative among many within academia (Dawkins, 2006; Ecklund & Park, 2009; Knight & Lomas, 2001). Opponents of the conflict theory have held that faith and science are not mutually exclusive concepts (Hess & Allen, 2008; Jaki, 1990; Stark, 2003; Wiker, 2011; Woods, 2005). The reality may be that each suggestion is at least partially true in that the particular faith tradition or lack thereof may provide a theoretical paradigm that acts as the lens through which and individual perceives the world, which thus makes possible, hinders, or completely stifles scientific advancement within a given culture (Hannam, 2011; Jaki, 2000).

Although the conflict theory originated during the Age of Enlightenment with such figures as Voltaire, Diderot, and Gibbon (Stark, 2003), it received renewed impetus at the end of the 19th century from American scientist and philosopher John Draper (1874), who advanced the notion of a backward Medieval Europe. In the book entitled *History of the Conflict between Religion and Science,* Draper seemed to have largely framed the debate concerning the historical relationship of faith and science (Ecklund & Park, 2009). His thesis held that Medieval Europe was controlled by the domineering, backward-thinking Catholic Church, which severely handicapped scientific development until the Age of Enlightenment freed people to pursue truth through empirical means alone (Hess & Allen, 2008; Pernoud, 1977/2000; Stark, 2003).

Draper (1874) depicted the development of science as a conflict between two contending powers: human intellect versus the oppressive Catholic Church. Following his work was a volume written by his friend and a cofounder of Cornell University, Andrew Dickson White (1896), entitled *A History of the Warfare of Science with Theology in Christendom*. These works and others are responsible for several myths that over time have developed into what people have commonly accepted as “facts,” which serve to obscure the actual, historical relationship of faith and science. One persistent example originally fabricated by White (1896) is the often repeated claim that Christopher Columbus and his crew were not sure whether or not they would fall off the edge of the earth when sailing across the ocean because they believed the earth to be flat (Singham, 2007; Stark 2003). This notion had no basis in fact but has continued to serve the purposes of those who wish to downplay the significance and accomplishments of pre-Reformation Europe (Singham, 2007). The Columbus myth became so well entrenched in the 20th century that even a respected scholar such as the Librarian of Congress’s Daniel Boorstin (1983) took it for granted as incontrovertible in his widely read book *The Discoverers* (p. 592). Concerning the Columbus myth, Stark (2003) observed, “Trouble is that almost every word of White's account of the Columbus story is a lie” (p. 122).

Another persistent legend perpetrated by those who wished to downplay Medieval European achievements in science is that the Catholic Church was opposed to human dissection (Hannam, 2011; Stark, 2003). Another still is the claim that Medieval people never knew the time of day because they had not invented clocks yet, hence they were living in the Dark Ages (Pernoud, 1977/2000). An additional, commonly repeated myth is that during the Middle Ages the Catholic Church strenuously inhibited academic freedom (Hannam, 2011; Lindberg, 1992; Stark, 2003; Woods, 2005). Still another is the claim by White (1896) that the Catholic Church, through an edict by a pope, forbade the practice of chemistry. Draper (1874) authored another fable by claiming that a pope from the Middle Ages said fervent prayers and required that all of the church bells in the city be rung in order to change the path of Halley's comet which, Draper claimed, was thought to be threatening the earth (Walsh, 1915). There have been a number of frequently repeated stories surrounding the Galileo affair, which although ill-advised, was not at all what most people commonly believe it to be. Nonetheless, probably the most egregious and entrenched offenses are the now conventionally accepted designations given to entire periods of history: the Dark Ages, Middle Ages, Medieval Period, Renaissance, and the Age of Enlightenment. These names assigned to entire historical eras reflect the biases of scholars who lived and wrote in later periods of history (Hannam, 2011; Lindberg, 1992; Pernoud, 1977/2000; Stark, 2003; Woods, 2005).

Essentially, historians have perpetrated the idea that the period between the fall of the Roman Empire and the advent of the Renaissance was an interruption to mankind's progress and that little or no scientific progress occurred during the period (Hannam, 2011; Lindberg, 1992; Stark, 2003; Woods, 2005). Unfortunately, these and similar myths and misrepresentations have deeply penetrated Western society and are so widely repeated that they have become common knowledge (Pernoud, 1977/2000). These and other related legends are the fodder used by proponents of the conflict theory, which holds that faith and science are antithetical to one another, to bolster their argument (Hannam, 2011; Lindberg, 1992; Pernoud, 1977/2000; Stark, 2003; Wiker, 2011; Woods, 2005).

Notwithstanding the commonly accepted narrative, the fact remains that between the 10th and 16th centuries Europe witnessed unprecedented scientific development (Jaki, 2000; Royal, 2006; Stark, 2003; Woods, 2005). In light of this and other factors, one scholar proposed that in light of the extraordinary intellectual achievements of the period between the fall of Rome to the Renaissance, it is incomprehensible that the era is known as *the Dark Ages* (Hannam, 2011). Still, conflict theorists have continued to represent the entire period of human history between the fall of the Roman Empire to the Renaissance as a period of unmistakable retrograde and decline (Lindbergh, 1992; Pernoud, 1977/2000; Stark, 2003). For example, Knight and Lomas (as cited in Woods, 2005) concluded, “The establishment of the Romanized Christian era marked the beginning of the Dark Ages…when the lights went out on all learning…It lasted until the power of the Roman Church was undermined by the Reformation” (p. 3).

Vast disagreement has been present among contemporary scholars concerning the actual and appropriate relationship of faith and science (Dawkins, 2006; Ecklund & Park, 2009; Harris, 2004; Jaki, 1990; Stark, 2003; Schaefer, 2011; Woods, 2005). Since the Age of Enlightenment, the actual role the Catholic Church played in the development of science has been at the center of the debate. With this study I intended to explore how the theoretical paradigms or worldviews held through time by people of different religions and cultures affected their ability or inability to achieve continued scientific progress, and, in so doing, explore Christianity's role in the development and progress of science, which can serve to inform the current debate, which at its most fundamental level concerns the actual, historical relationship of faith and science.

Religious beliefs and scientific perceptions are distinct cultural elements. Justifiably, culture remains a critical consideration in educational curriculum (Zimmerman, 2002). Diversity of opinion and respect for those who hold opposing sentiments are foundational to scholarship and the educational process. A more clear understanding of how the most prominent faith traditions have understood and interpreted scientific claims may serve to help diminish the persistent cultural clash between some faith traditions and the educational culture. A thorough examination of the veracity of the conflict theory itself may serve to diminish what has now developed into a pronounced cultural conflict.

The most important objective of this study is to help ease the cultural dilemma, resulting from the continuing clash over faith and science, which is affecting so many students today. For many students the most important cultural groups in their lives are their family unit, religious faith tradition, and their educational environment (Scheitle, 2011; Zimmerman, 2002). However, many students in the Western world have observed what they perceive is a clash between those three cultural groups. The particular family beliefs–atheistic, theistic, or agnostic–are not particularly relevant because neither side is content with the ongoing struggle. This study is intended to help diminish the conflict between family, religious, and educational cultures by providing a clearer understanding of how those of various faith traditions have historically understood and interpreted scientific claims.

Problem Statement

Scholars have continued to strenuously debate Christianity's role in the development of science (Dawkins, 2006; Catholic Answers, 2004; Turner, 1908; Harris, 2004; Moore & Cotner, 2013; Moore & Cotner, 2009; Stark, 2003; Wiker, 2011; Woods, 2005). Educators have continued to grapple with effective methods to address the tensions between science, religious teachings, and religion's influence on the development of science. The ongoing debate concerning the proper relationship of faith and science affects many students, who are often faced with a choice between two basic cultural value systems: their family values and their educational experience (Scheitle, 2011; Zimmerman, 2002). Unfortunately, a thorough analysis of the history of scientific thinking, as it pertains to faith, is not readily available to clarify and support that conversation, and I intended this study to fill that gap in the literature.

Nature of Study

The appropriate research paradigm for this study was qualitative, and the specific approach I took was the historical approach methodology. Historical research encompasses the systematic examination of past events for the purpose of better understanding and interpreting the meaning of those events (Haider, 2011). The historical approach methodology enables the researcher to interpret personalities, ideas, and nuances in light of their influence on history. Analysis of primary, secondary, and tertiary sources are an excellent means of conducting longitudinal analysis that may stretch over years, centuries, or even millennia. Rigorous historical research is not simply the collection of facts, dates, personalities, and events, but is principally concerned with properly interpreting and understanding the data for the purpose of offering counsel in the present and for the future (Heck, 2004).

Public schools in 2014 are in the midst of a debate concerning the historical relationship of faith and science, which is reflective in two principal issues, the first of which is a myriad of regularly repeated distortions related to religion and science through time (Pernoud, 1977/2000). The second issue concerns the century-long struggle over whether or not evolution should be taught in American public schools (Eckland & Park, 2009). I judged these attributes inherent in the historical approach methodology to be the most appropriate means of investigation for exploring the central research question and subquestions herein. This historical research focused on exploring the complex issues surrounding the historical relationship of faith and science as a means to ease tensions and inform the related debate encircling public schools in 2014 (Scharrer, 2011).

Research Questions

Central Research Question

What additional facts and insights may be learned through a thorough exploration of the historical relationship of faith and science, in light of current challenges confronting educators?

Subquestions

1. What significance, if any, can be attributed to faith in the development of science, during the period between the fall of the Roman Empire through the Renaissance?
2. What importance does the historical origins and progress of science hold in informing the continuing creationist versus Darwinist conflict within education?

Research Objectives

The primary goal of this historical approach study was to assist educators in their understanding of the actual relationship between faith and science as they grapple with addressing the claim by some that an inherent conflict exists between faith and science. Hence, the first objective of this study was to investigate the actual role Christianity played in the development of science during the Dark Ages and through the Renaissance era. Questions related to faith and science are often first debated among scholar practitioners within higher education and the results of these exchanges very often trickle down and affect curricula at the lower levels of education. I intended this research to contribute to the scholarly record in relation to the ongoing debate over the relationship of faith and science.

The second objective of this research was to provide an accurate accounting of the role Christianity played in the development and progress of modern science in light of the cultural dilemma faced by so many students today, who find themselves in the midst of the struggle between creationists and Darwinists. Students often find that their family and/or religious values sharply conflict with the information found in their educational curriculum (Larson, 2003). The result is that many students are then faced with having to choose between their teacher's values and those of their parents. I hoped that this study would offer background and information that provides context to the debate for the scholarly community, educators, and students alike.

Operational Terms and Definitions

The following operational terms and definitions emerged during the data analysis phase of this research, and this analysis is contingent upon a proper understanding of their use herein. As they are provided for purposes of clarity, these terms are defined in light of the specific contexts in which they are used within this dissertation. That is, the terms defined herein often have multiple meanings and uses, but the particular aim here is to describe their meaning in reference to this study.

The Nature of Science

The word *science* derives from the Latin word *scienta,* which means *knowledge* (Hannam, 2011). In the Hellenistic ancient world, this broad definition of science encompassed all intellectual disciplines including philosophy, theology, and politics. In ancient Greece and throughout the Middle Ages, the study of the natural world was a separate discipline referred to as *natural philosophy* (Lindberg, 1992; Woods, 2005). In a sense, the natural philosophers were the scientists of their day, insofar as they sought to understand nature (Hannam, 2011). The concerns for this study were the factors that eventually contributed to the development of the empirical sciences, the methods through which they were formulated, and the uses to which they were applied (Lindberg, 1992).

Hence, the terms *science* and *natural philosophy* will be used interchangeable in parts of this discussion and will signify what is now commonly understood as empirical science. Of note, two key relevant historical figures discussed in this chapter are Aristotle and Thomas Aquinas, who defined science in much more general terms. Aristotle (Hagen, 1912, para. 1) defined science "as a sure and evident knowledge obtained from demonstrations" and Aquinas perceived science to be the "knowledge of things from their causes" (para. 1). Their respective definitions were too general to apply to this dissertation, however, after reviewing the historical record. Instead, a more narrow definition was needed. For the purposes of this analysis, *science* was defined more narrowly in accord with the accepted attributes of empirical science, which are (a) the development of theory; (b) controlled experimentation; and (c) careful observation of results (Lindberg, 1992; Stark, 2003; Woods, 2005).

Science involves organized efforts to formulate explanations of nature, which are always subject to revisions, corrections, and further development through systematic observations (Stark, 2003). Empirical science does not represent mere random discovery, apart from development of theory and controlled experimentation, and thus excludes most human endeavors to explain and control the material world (Stark, 2003). For instance, the ancient Chinese randomly discovered that a needle floating in liquid always points north (Hannam, 2011), but their discovery was made apart from experimentation and the Chinese never endeavored to explain the phenomenon or apply it usefully (Jaki, 1990).

Even technological progress, though sometimes considerable, does not necessarily rise to the level of science and may better be described as crafts, learning, skills, or applied knowledge (Stark, 2003). For instance, as discussed below, the ancient Egyptians were able to build elaborate structures, but without the advantages afforded by mathematical science that undergird modern engineering and architectural design. Similarly, observation in and of itself–apart from theory and experimentation–does not rise to the level of empirical science. As many ancient civilizations excelled in astronomical observation, until those observations were linked to testable theories they remained mere "facts" (p. 125). Moreover, not all abstract statements offering explanations of natural phenomena qualify as scientific theories. For instance, the ancient Mayans attributed eclipses in the heavens to the sporadic appetite of cosmic ants to eat away a portion of a celestial object, which cannot qualify as a scientific theory (Jaki, 1990).

Scientific research consists of making observations that are relevant to empirical predictions about nature and natural phenomena (Hannam, 2011). This analysis concerns the progress of science, as it pertains to comprehending the natural world, as a means to inform the current challenges facing educators regarding the authentic relationship of faith and science.

Relationship of Faith and Worldview

The subject of this chapter concerns an analysis of the extent to which collective worldview was influenced by religious beliefs for most prominent civilizations in history, in relation to their perceptions of nature and consequent desire to explore or apathy toward nature. In the context of this discussion, the concept of *collective worldview* refers to a people's shared, preconceived perception of the workings of nature (i.e., the driving force or forces of nature). Worldview is crucial for the reason that it underlies other ideas, even the most fundamental ideas, such as how a people perceives and understands the world around them (Hannam, 2011). "Many seem to take their own beliefs so much for granted that they are oblivious of them as beliefs, so obvious, normal, commonsensical, and incontestable do their convictions seem" (Gregory, 2012, The Central Paradox of Science section, para. 4). Because worldview is a fundamental and essentially unconscious human perception, the vast majority of people–even entire civilizations–rarely give much thought to the deep-seated factors that shape their worldview (Hannam, 2011). For example, to the observer standing on the Earth, the sun appears to circle the Earth and people saw no need to challenge that hypothesis for almost 1,500 years.

One primary factor shaping individuals' worldview was the religion they practiced in the particular civilization (Hannam, 2011). Religious faith or the renunciation of faith are, by nature, often the most innate and most fervently held of all human convictions (Jaki, 1990). Consequently, religious faith or the exclusion of religious faith is arguably the most significant factor in shaping one's worldview (Woods, 2005). Thus, a civilization's religious beliefs or faith convictions are foundational to how its members perceive and understand the natural world.

Forms of Religious Worldviews

Animism. Animism is the religious worldview that all physical entities (i.e., plants, animals, and inanimate objects) possess souls, a spiritual essence, and even desires ("Animism," 2013). The animistic worldview characteristic of ancient civilizations, although also present in the contemporary New Age movement (Taylor, 2011), draws no distinctions between purely physical reality and the spiritual world. Rather, the physical and spiritual are believed to be intermingled and inseparable. Animism is similar to and is often an element of pantheism, in that both religious worldviews attribute supernatural forces to natural phenomena.

Cabalistic. Cabalism is usually associated with esoteric and often confusing admixture of mystical beliefs that are usually restricted to an enlightened inner circle ("Cabalistic," 2013). Cabalistic beliefs are often associated with conspiracy theories and in European culture came to be associated with occult practices and beliefs (Makow, 2003).

Christianity. Discussed further below, the Christian religion is a monotheistic religion, encompassing a definite system of beliefs and practices that were taught by Jesus Christ in Palestine during the first century A.D., and handed down to chosen men, known as the Apostles (Keating, 1908). In contrast to other religions cited herein, the biblical conception of creation *ex nihilo* (i.e., *out of nothing*) was expounded, clarified, and defended by the early Church Fathers, as they argued against the eternity of the universe and matter (Siegfried, 1908). The central doctrine of Christianity is the belief that the unity of the Godhead subsists in three distinct Persons: the Father, the Son, and the Holy Spirit (Joyce, 1912). Christians believe that Christianity is the fulfillment of the Jewish religion, as they believe that Jesus Christ is the Messiah, whose coming was foretold by the Hebrew prophets and recorded in Old Testament scripture (Keating, 1908). The life and teachings of Jesus Christ were recorded by His Apostles and first disciples and comprise the books of the New Testament. Christian beliefs and practices were first defined, formalized, and enacted by the successors of the Apostles or Church Fathers, during the patristic period (approximately 100 – 800 A.D.; Pohle, 1912).

Conflict theory. Conflict theory is the claim first proposed during the Age of Enlightenment, which purports that faith and science, particularly Christianity and science, are diametrically opposed concepts, mutually exclusive human endeavors, and are even “at war” (Draper, 1874; Jaki, 2000; Pernoud, 1977/2000; Stark, 2003).

Creationism. Creationsim is the belief that the creation account in the Book of Genesis should be understood literally, as representing a literal 6-day creation, wherein God brought all matter and life forms into existence in essentially their present form, less than 10,000 years ago (Horn & Wiedenhofer, 2008; Skehan & Nelson, 2000).

Darwinism. Darwinism is an evolutionary theory that maintains the evolution of species occurs through three interrelated, but distinct processes: random mutation, natural selection, and common descent (Darwinism, 2008). The majority of Darwinists specifically hold to an atheistic point of view, wherein the universe perceived to be infinite or have come into existence through strictly natural processes, thus eliminating the need for God (Royal, 2006; Wiker, 2011).

Emanationism. Emanationism is the belief that all things flow or descend from an underlying principle or reality, usually termed *the Absolute* or *Godhead* (Kleinman, 2007). Emanationism opposes the Christian belief that creation took place *ex nihilo* (i.e., *out of nothing*), as emanation proposes that the entire composition of the universe is eternal, so creation could not have occurred *ex nihilo*. Emanationism is characteristic of pantheism and occult practices (i.e., the use of spells, incantations, tarot card reading, astrology forecasts, etc.), to call upon and interpret the intentions and desires of perceived evil forces (Crowley, 2003).

Evolution. This is the process by which various life forms are thought to have developed, diversified, and evolved from earlier forms during the history of the earth (Horn & Wiedenhofer, 2008; Skehan & Nelson, 2000).

Judaism. Judaism is the religion of the ancient Hebrew people, which is characterized by the belief in one transcendent and omnipotent God (i.e., monotheism), Who revealed Himself through the prophets Abraham, Isaac, Jacob, Moses, and a series of other Hebrew prophets ("Judaism," 2013). The Old Testament scriptures record the history of the Jewish people and their relationship to God, as revealed through the Hebrew prophets. Another significant aspect of Judaism is the foretelling of the Messiah, the Promised One, the Anointed One, the Christ (Hitchcock, 2012), whom they anticipate will liberate their people through military and/or political means. The Jewish people do not accept Jesus Christ as the Messiah and are still anticipating the arrival of this great liberator. Judaism is the most ancient monotheistic religion of record (Aiken, 1911) and although the Jewish people lived amid pagan and pantheistic people who believed the universe to be eternal, divine, or controlled by the whim of the pagan gods, the Jewish people rejected those and similar notions. They held to belief in an omnipotent Creator, Who created at a singular moment in time ("Judaism," 2013).

Mythology. Religion and mythology are distinct concepts that share interrelated characteristics (Aiken, 1911). Both religion and mythology concern the spiritual or supernatural and characteristically hold particular importance within particular communities, but mythology is most accurately understood as a component of religion (Lewis, 1970). Very often, religion embraces aspects of mythology, but most commonly religion signifies a broader experience, often encompassing ritual, theology, morality, and mystical experience. Although particular mythologies are common to particular religions, a myth that is disconnected from its religious roots can become synonymous with a legend or folklore (Magoulick, n.d.).

Natural philosophy. Derived from the Latin *philosophia naturalis*, natural philosophy denotes the philosophy of nature or the study of nature and the physical universe. Natural philosophy was practiced by the ancient Greeks and throughout the Middle Ages and represents the beginnings of modern science. In a word, natural philosophers were the scientists of their day (Hannam, 2011; Lindberg, 1992).

Paganism. Paganism is traditionally understood to be synonymous with polytheism (i.e., worship of multiple deities), is commonly attributed to Greek and Roman cultures (Pagan, 2013), and is practiced in the contemporary New Age movement (Taylor, 2011). However, paganism was practiced by every recorded pre-Christian society except Judaism, which is monotheistic (Jaki, 1990; "Judaism," 2013).

Pantheism. Pantheism is a religious belief that equates God with all material substance and all natural phenomena, including the forces of the universe ("Pantheism," 2013). In the pantheistic consciousness, God does is not outside or beyond the physical world and does not possess conscious freedom, but *is* the physical world itself. Thus, pantheism presupposes an unpredictable universe, not subject to laws of nature, but the actions of the divine universe. Pantheism was present in the majority of ancient cultures, including ancient Egypt, Greece, India, and China, and is characteristic of both Buddhist and Hindu beliefs (Jaki, 1990), although it endures into the present time within the New Age movement, as "the religion of the visible Universe" (Crowe, 2008, p. 125).

Science. In the context of this dissertation, science denotes the empirical investigation of natural phenomena. Because the universe is understood to operate through regularities, systematic, empirical investigation of those regularities can be undertaken and understood. By its nature, science is limited to explaining the natural world by means of natural processes. Thus, supernatural causes or explanations fall outside of the bounds of science (Skehan & Nelson, 2000).

Assumptions, Limitations, and Scope

Several characteristics serve to identify and define historical research, but the principal objective is to uncover truth about past events (Heck, 2004). One goal of an historical study may be to uncover evidence that leads to new claims. An historical study may attempt to develop explanations of past events through rigorous investigation of material. Another objective of historical research may be to order what is already known in a way that provides a new perspective on the past, such as, by refuting the evidence for competing theories or claims. Additionally, an historical study may seek to inform present discussions of policy issues or problems by building theory about how past policy decisions have evolved through time. Ultimately, rigorous and honest historical studies contribute to building a knowledge base about past events and the new knowledge can serve to inform present discussions (Windschuttle, as cited in Heck, 2004).

By its very nature, historical research focuses on change over time within events that cannot be repeated (Heck, 2004). Unlike other forms of qualitative research, the focus of historical studies is centered on specific events and circumstances, as opposed to generalizations about data patterns. Moreover, historical research is not oriented toward prediction, as are some other designs. The result is that the underlying logic of historical research is very different from some other types of research designs (Windschuttle, as cited in Heck, 2004). Historical researchers cannot separate context, such as, outside forces, from the phenomenon under study, so the consequence is that historical research concerns the description and explanation of unique events. Essentially, historical research is an appropriate methodology for interpretation of past events, but is not an appropriate research approach to assist in predicting how policies and events will influence the future (Heck, 2004).

The first significant limitation of historical research concerns subjectivism in both the data collection and data analysis processes (Heck, 2004). Unchecked subjectivism results in researcher bias. Historical researchers can knowingly or unwittingly skew their research results by implementing inferior sampling strategies during the data collection process. For reasons of objectivity, data must be collected that both confirms and disconfirms or challenges the stated research hypothesis (Haider, 2011). In order to ensure completeness, primary, secondary, and tertiary data have been gathered from a variety of sources and source types in the course of this research. The goal of rigorous historical research is to achieve transparency by demonstrating that the research conclusions are accurately supported and drawn from the research data. The data analysis phase must entail accurate categorizing, coding, and interpretation of each data source in its proper context, otherwise, the research results will be skewed and rendered invalid (Heck, 2004).

A second disadvantage to the historical approach methodology commonly encountered by researchers is that the process can be very time consuming and in some cases, costly (Heck, 2004). In many cases the data collection process itself can be daunting because of the vast quantity of data and data sources available to the researcher. Moreover, data analysis can be formidable for similar reasons. To remedy the daunting nature of the data collection and data analysis processes within the historical approach methodology the researcher must define the bounds of the study. By framing the study in specific terms related to a specific timeframe, singular phenomenon, and/or a specific series of events, the historical researcher can sufficiently narrow the scope of the study, thereby streamlining the research process. The use of the Internet and specifically designed computer software can also greatly enhance and streamline both the data collection and data analysis processes (Miles & Huberman, 1994).

Theoretical Framework

The theoretical framework that guides this study is grounded in the proposition that historical literacy informs and improves educational practice (Brown, 2007). The present difficulties, resulting from the continuing clash between the creationist worldview and conclusions of empirical science, underscore the need for a comprehensive exploration of the conflict by way of its antecedents, which stretch back through history. History as a hermeneutic for education can cultivate historical literacy, which is an essential element of a broad education and can assist students to form intelligent opinions and make informed decisions concerning the authentic relationship of faith and science (Gilderhus, 2010). Moreover, this historical review is intended to help separate myth from reality in light of the fact that regularly repeated myths encircling the charge that faith and science are at war have significantly blurred the historical record (Ecklund & Park, 2009).

Rigorous historical research, guided by a justifiable theoretical framework and undertaken as an honest search for new knowledge, can significantly contribute to building a reliable knowledge base concerning the past (Heck, 2004). Windshuttle (as cited in Heck, 2004) observed that historical research can enable the researcher to describe and explain past events in their appropriate context and perspective. In the end, the principal aim of historical research is to attempt to uncover the truth about past events. Historical researchers frequently propose competing claims or theories concerning past events, their significance, and meaning. Historical research may engender new claims or theories based on a new perspective or synthesis of past events.

The research questions herein are structured in such a way as to provide a tangible means to address the most important aspects of the controversies currently being debated in public schools, concerning the relationship of faith and science. In the end, scholarly, historical research may result in a dependable refutation of the evidence for competing claims and offer a valid description of the past.

Potential Weaknesses

The most significant potential weakness of the historical research methodology is the potential for researcher bias (Heck, 2004). The historical research methodology requires subjective interpretation of data, which can lead to researcher bias. In light of the tendency toward researcher bias, historical researchers attempt to locate and analyze a number of independent sources and if those sources contain the same message or conclusion the credibility of that message or conclusion is greatly enhanced.

An additional method to safeguard against researcher bias is to examine any reasonable, disconfirming or alternative explanations of relevant events and their related affects (Heck, 2004). That is, reliable sources that provide opposite motivations and explanations must be included and given the same weight during the data analysis process. Another precaution against subjectivism is in examining historical events in their proper context, which can only be accomplished through a comprehensive analysis of both the antecedent and contemporaneous historical events under study.

Maintaining academic integrity is a primary objective of this research, which can only be achieved through a thorough examination of both confirming and disconfirming sources during data collection, in conjunction with accurate scrutiny of those sources during the data analysis process. The subsequent research conclusions will be informal inferences that are firmly grounded in a convergence of antecedent probabilities (Newman, 1870). That is, in keeping with the qualitative research paradigm and the historical approach methodology, a preponderance of the evidence will lead to an interpretation of the past and the consequent research conclusions.

Bounds of the Study

The focus of this research is the historical relationship of faith and science, which understood in its proper context, can provide the essential background required to apprehend the ongoing creationists versus Darwinists controversy in light of its antecedents. A clearer sense of how faith influenced the development of science may emerge through a comprehensive exploration of how the various prominent world cultures' faith traditions shaped their worldview, including their perception of natural phenomena (Hannam, 2011). Science first began to flourished as a discipline in Christian Europe during the Middle Ages (Jaki, 2000; Woods, 2005), but various faith traditions profoundly influenced perceptions of natural phenomena prior to and subsequent to the emergence of Christianity (Jaki, 1990).

Thus, to sufficiently address the research questions herein, a study of how faith influenced scientific development through time and in various prominent world cultures must be performed. The aforementioned myths surrounding faith and science and the continuing controversy pertaining to science curriculum content and pedagogy can best be understood through the lens of history. The intersection of faith and science within the most prominent world cultures will be analyzed, leading to an in-depth examination of the creationist controversy, which is the most prominent conflict between widely held religious beliefs and scientific conclusions currently disrupting science education in 2014 (Scharrer, 2011; Skehan & Nelson, 2000).

Significance and Implications of the Study

The debate over the actual or appropriate relationship of faith and science has a very long history (Draper, 1874; Stark, 2003; White, 1896) and in the United States, is notable for an element of increasing polarization between groups (Dawkins, 2006; Harris, 2004). The long-standing conflict over science course content continues in local public school districts, state legislatures, the public sphere, and within the United States courts (Larson, 2003). One result of the legal and very public conflict has been a deleterious effect on the discipline of education (DeWolf, Meyer, & DeForrest, 1999; Larson, 2003). Many administrators, curriculum development specialists, and teachers are simply unsure of what direction to take in relation to what science content is acceptable for the classroom and how best to present that content. Moreover, commonly repeated and accepted myths have, over time, permeated science curriculum content (Boorstin, 1983; Stark, 2003). But the ultimate concern remains the students themselves, who in addition to being taught myths that may be advancing a supposed conflict between faith and science, are frequently being compelled to choose between what are very often their most vital and personal cultural groups: their family values, their educational environment, and often their religious faith tradition (Scheitle, 2011; Zimmerman, 2002).

The hope is that this historical study will provide a more clear understanding of the most significant past events related to the development of science as a discipline, including what role, if any, faith played in that development. Various social groups have taken up entrenched positions that are very often uninformed and bolstered by falsehoods and myths. It is ironic that education, which is ideally suited to see through myths and uncover facts, has been forced to the center of the creationist conflict for the last 150 years. Significant social change can be attained if educators are freed to teach science apart from myth and this study is directed toward achieving that end.

Summary and Preview of Major Sections

Headlines in 2014 proclaimed faith and reason are at odds (The Huffington Post, 2014). The argument is encouraged by the legal wrangling over whether or not public schools should be mandated to teach creationism and/or intelligent design alongside the theory of evolution (Larson, 2003; Scharrer, 2011). Scholars continue to advance the now commonly accepted, conflict theory narrative that asserts Christianity has historically, actively hindered scientific development (Royal, 2006). The argument has reached beyond local school boards at the district level and advanced to state legislatures and the United States courts (Larson, 2003). Educators, curricula development specialists, and many students find themselves in the midst of the continuing controversy. For many students the ongoing conflict amounts to a cultural clash between their family values, religious faith tradition, and educational experience (Scheitle, 2011; Zimmerman, 2002). A more clear understanding of how various faith traditions have understood and interpreted scientific claims may serve to help diminish the conflict between the disputing cultural groups.

The following chapter 2 describes the content of the review, as well as the organization, and proposed iterative search process to be implemented. The association of the proposed research questions to the problem statement is described and an overview of the literature, including comparisons of contrasting points of view are presented in the succeeding chapter. Chapter 2 expounds on the connection this proposed study will have with previous related research. The theoretical framework which guides this research is presented in light of its relevance to the historical approach methodology and how it can be implemented to the benefit the discipline of education.

Chapter 3 describes how the research design derives logically from the research problem. The qualitative historical approach methodology is proposed as the most logical choice for this study and justified based on its strengths in regards to the research objectives and limitations inherent in other possible choices of research paradigms. The role of the researcher is discussed in relation to strengths and limitations of the historical approach methodology itself, which is subject to researcher bias appropriate safeguards, are not in place. How the proposed research question and subquestions align with the proposed methodology, research objectives, data collection, and data analysis procedures is presented in chapter 3. Data collection and analysis procedures are discussed in detail, including how data will be selected, analyzed, including discrepant cases, and how emergent themes will be deciphered and interpreted.

Chapter 4 is a review of the research pertaining to the historical relationship of faith and science, as it relates to education. How various faith traditions throughout history have shaped the worldviews of entire civilizations, including their perceptions of the natural world, is directly related to their willingness or unwillingness to pursue scientific enquiry. Moreover, science educators in 2014 are immersed in a struggle between creationists and Darwinists over science curriculum and pedagogy, which chapter 4 addressed in depth.

Chapter 5 provides a concise summary of the study purpose, nature, and findings and suggestions are made for further research. The most significant social implications of this study are also discussed in relation to the means by which the study findings can be implemented within education.

The long-standing debate encircling education in 2014, concerning religion's role in science, has taken on a variety of forms in the last three centuries. The primary claim by some is that faith and science are in a state of indissoluble conflict (Wilson, 2002), which is a claim that first arose during the Age of Enlightenment (Scharrer, 2011). The claim that science and faith are in inextricable conflict later gained new momentum in the mid-19th century with the 1859 release of Charles Darwin's *On the Origin of Species*. These claims that propose faith and science are incompatible enterprises have deep historical roots and continue to have negative effects on science education in American public schools. Thus, a more detailed analysis of the related background and issues related to faith, science, and science education have been addressed in the following chapter.

Chapter 2: Literature Review

Research Problem

The relationship of faith and science, and in particular Christianity's role in the development of science, continues to be strenuously debated within the academic community (Dawkins, 2006; Harris, 2004; Jaki, 2000; Knight & Lomas, 2001; Stark, 2003; Wiker, 2011; Woods, 2005). Educators continue to grapple with effective methods to address the tensions between science and religious teachings as well as how to accurately convey the historical relationship of faith in the development of science (NCSE, 2008; Pianta, Belsky, Houts, & Morrison, 2007). On a more basic level, the discipline of education is positioned between conflicting sides in a long-standing debate that reaches to the very core of science education, concerning how science should be conducted and conveyed to students in the classroom. The perceived conflict between faith and science has reached beyond the classroom and is regularly argued within state legislatures and litigated within the United States court system (Le Beau, 2007; NCSE, 2001). The ongoing debate concerning the proper relationship of faith and science affects many students, who regularly find themselves faced with having to choose between three basic cultural value systems: their family's values, their religious beliefs, and their educational experience (Scheitle, 2011; Zimmerman, 2002). Regrettably, an in-depth analysis of the history of scientific development, particularly as it pertains to faith, does not seem readily available to clarify and support that conversation.

Research Purpose

The principle objective of this study was to fill the gap in the literature concerning the historical relationship of faith and science for the purpose of helping ease the cultural dilemma confronting so many students and educators today, as a result of the perceived clash between faith and science (Scheitle, 2011; Zimmerman, 2002). I used the historical approach methodology to address the research questions, which necessitated an in-depth analysis of how faith and science interacted through history. The factors that propelled the progress of science, as well as the circumstances that effectively obstructed its advancement, are crucial elements of this effort to separate reality from falsehood in reference to how and where science began to flourish as a discipline. This study was intended to help diminish the conflict between families, religious groups, and the educational community by providing a more clear understanding of how various faith traditions have historically understood and interpreted scientific claims.

Literature Pertaining to Problem

The charge that underlies the ongoing conflict is the assertion that faith and science are, at minimum, incompatible, or at worst, best characterized by a “warfare model” (Russell, 2002, p. 3). Recent scholars have referred to this perceived discordant relationship of faith and science as the "conflict theory" (Ecklund & Park, 2009, p. 276), "conflict thesis" (Wilson, 2002, p. 14), or "military metaphor" (Russell, 2002, p. 3). The contention that faith and science are intrinsically opposed has its roots in the Age of Enlightenment (Schaefer, 2011; Stark, 2003) but has more recently gained momentum and become the commonly accepted narrative among countless scholars (Dawkins, 2006;

Harris, 2004; Knight & Lomas, 2001). Russell (2002) noted that "the notion of mutual hostility…[that] has been routinely employed in popular-science writing…by the media" is "deeply embedded in the culture of the West" and has "proven extremely hard to dislodge" (Russell, 2002, p. 4). Wilson (2002) observed: "The most prominent view among both historians and scientists in the 20th century has been a presentist conflict thesis" (p. 14).

In 2014, the most noteworthy example of a genuine conflict between a particular faith tradition and science, relative to education, appears to continue to be between creationists and evolutionists (Larsen, 2008; Le Beau, 2007; Marrapodi, 2012; NCSE, 2011; Scharrer, 2011). Regrettably, for close to a century the public schools have been the battleground of choice between these contending parties. Creationists or literal creationists believe in a literal 6-day creation, as described in the Book of Genesis (Numbers, 2002). As a result of their literal interpretation of Scripture, creationists reject any scientific claims of an old earth or universe. Most creationists believe creation occurred approximately 10,000 years ago, a view that conflicts with most basic science textbooks used in public schools, which put the age of the universe at approximately 13.7 billion years. Creationists also hold that all life forms were created in essentially their current form and, as a consequence, reject any scientific claim of an evolutionary process (Answers in Genesis, 2012; Larson, 2002; Numbers, 2002).

The particularly vexing difficulty confronting any effort to ease the tensions resulting from the creationist versus evolutionist conflict currently affecting public schools is the generally accepted perception that the discord simply cannot be resolved because faith and science are opposed (Jaki, 1990; Stark, 2003; Wiker, 2011; Woods, 2005). If faith and science are intrinsically opposed, then there would seem to be little or no hope that the creationist/Darwinist conflict can be satisfactorily resolved. In terms of the historical relationship of faith and science, the creationist versus Darwinist clash is a very recent phenomenon, originating in the latter half of the 19th century (Larson, 2003). However, faith and science have been intimately connected for millennia (Hannam, 2011; Jaki, 1990; Jaki, 2000; Lindberg, 1992; Stark, 2003; Wiker, 2011) and the historical relationship between the two may provide the key to easing the present tensions concerning science pedagogy and curriculum content (David & Kenyon, 1993; Larson, 2003).

Summary of Chapter Sections

Chapter 2 offers an in-depth description of the interrelatedness of each element of this study. It includes an in-depth description of how the methodology, data collection process, data analysis process, and research questions were designed to explore the expressed research problem and purpose. I discuss existing seminal research and related literature pertaining to the phenomenon and explain the iterative search process, data sources, and source types used in this research. The theoretical framework is explained and justified, in terms of its relationship to the historical approach methodology, as well as how the methodology has been applied in other related studies.

Library Databases and Search Engines

A comprehensive data collection process, which includes the accumulation of both confirming and disconfirming cases, requires the use of a variety of academic, popular Internet, and electronic sources (Miles & Huberman, 1994; Patton, 2002). The primary academic databases accessed for this dissertation were as follows: Academic Search Complete/Premier database; Education Research Complete database; 3) Education Resource Education Center (ERIC) database; Google Scholar database; ProQuest Dissertations & Theses (PQDT) database; and ProQuest Social Sciences database.

The primary higher education Internet sites accessed for data collection within this dissertation were as follows:

- Cornell University Law School website
- Florida State University website
- George Mason University website
- Ohio State University website
- Rice University website
- Simon Fraser University website
- University of California at Berkeley website
- University of Florida website
- University of North Carolina at Pembroke website
- University of Notre Dame website
- University of Regina website
- University of Texas website
- University of Virginia website
- Walden University Research Center website

Other scholarly sites accessed for resource and reference material purposes are as follows:

- American Museum of Natural History (AMNH) website
- Catholic Education Resource Center (CERC) website
- Catholic Encyclopedia website
- European Cultural Heritage Online (ECHO) website
- National Aeronautics and Space Administration (NASA) website
- National Association for Research in Science Teaching (NARST) website
- National Science Foundation (NSF) website
- William Cronon of University of Wisconsin at Madison website
- Vatican Archives

Popular websites used for data collection purposes within this dissertation were as follows: (a) AltaVista; (b) Answers in Genesis; (c) Evolution News; (d) Google; and (e) NCSE. The aforementioned academic databases and higher education, scholarly, and popular websites do not comprise the entirety of electronic and Internet sites referenced, but comprise the principal sources of electronic information.

Key Search Terms

The prime objective of this dissertation is to explore the proposed research questions through comprehensive historical analysis, so as to better understand and interpret the meaning of the events related to the central phenomenon under study (Haider, 2011; Heck, 2004). The following key search terms and phrases embrace the most prominent aspects of the central research problem and are aligned with the proposed research questions:

- Education and evolution and science curriculum and conflict
- Creationism and Darwinism
- Creationism and evolution and students
- Creation science and textbook or science curriculum
- faith and science
- relationship of faith and science
- science and religion
- Christianity and science
- science and faith and opposed
- Pantheism and science
- Science curriculum and legal battle or court cases
- cultural groups and students
- peer groups and adolescents
- Historical approach or historical methodology or historical research
- Data collection and data analysis and historical research

In addition to the above search terms and phrases, the search criteria will also include key individuals who are germane to this proposed study, such as, Copernicus, Galileo, Roger Bacon, Charles Darwin, etc. The above listed key search terms do not, of course, exhaust the proposed search criteria, but serve to demonstrate the general scope and intention of the electronic search criteria proposed herein.

Iterative Search Process

Scholarly rigor and the historical approach methodology require a comprehensive search for both confirming and disconfirming evidence or accounts related to the central phenomenon (Miles & Huberman, 1994; Patton, 2002). A thorough search process necessitates the inclusion of a variety of data sources and types (Haider, 2011; Heck, 2004), as well as repetition of key terms and phrases within a variety of electronic sources and databases (Miles & Huberman, 1994). Although it is not possible to list every aspect and detail of the iterative search process the following examples are provided, which serve to demonstrate the alignment of the key search terms and phrases within the various types of electronic sources. Similar search terms and phrases were also used interchangeably within both academic and popular search engines and databases, such as, http://www.altavista.com/; http://www.google.com/; http://www.newadvent.org/cathen/; and http://www.vatican.va/archive/index.htm:

- Academic Search Complete/Premier database; Education Research Complete database; Education Resource Education Center (ERIC) database; Google Scholar database
    - Education and evolution and science curriculum and conflict
    - Creationism and Darwinism
    - Creationism and evolution and students
    - Creation science and textbook or science curriculum
    - faith and science
    - relationship of faith and science

  - science and faith and opposed
  - Science curriculum and legal battle or court cases
  - cultural groups and students
  - peer groups and adolescents
- ProQuest Dissertations & Theses (PQDT) database; ProQuest Social Sciences database
  - Historical approach or historical methodology or historical research
  - Data collection and data analysis and historical research
  - Data collection and data analysis and data coding and historical
  - Historiography and science
  - Science and historical research

Coping with Partial or Incomplete Information

As is the case with most academic studies, an abundance of information exists in reference to some aspects of this proposed study, but is lacking in other areas (Maxwell, 2005; Miles & Huberman, 1994). For example, much information on the origins and subsequent enlargement of the creationist movement beginning in the latter half of the 19th century is extant (Larson, 2002; Numbers, 2002). Likewise, the history of Darwinism has also been well documented by scholars (Stark, 2003; Wiker, 2011). Similarly, the origins and subsequent historical development of the clash, including the ongoing legal confrontations, between creationists and Darwinists has been studied in some detail (Larson, 2002; Numbers, 2002). However, although the historical relationship of faith and science has been studied, due to the extent to which the conflict thesis has permeated Western culture, only a small group of specialists know the historical realities. Stark (2003) commented, “The reason we didn't know the truth concerning these matters is that the claim of an inevitable and bitter warfare between religion and science has…been the primary polemical device used in the atheistic attack on faith" (p. 123). Through the centuries, false claims about the relationship of faith and science have been used as weapons in the battle to "free" humanity from the "fetters of faith" from figures such as Voltaire, Thomas Hobbes, Carl Sagan, and more recently, Richard Dawkins (Stark, 2003). Yet, a proper understanding of the historical relationship of faith and science is essential to understanding and hopefully easing the cultural clash between creationists and evolutionists, which is having a deleterious effect on education in 2014. Moreover, a clear account of the historical relationship of faith and science will reveal the inadequacies of the conflict theory.

Unfortunately, the academic record concerning the historic relationship of faith and science is incomplete and generally reflects the polarization of the issue, so prevalent in the present popular culture – a polarization prompted by the presupposition that faith and science are opposed or simply incompatible (Dawkins, 2006; Eckland & Park, 2009; Harris, 2004). In order to help alleviate the present creationist versus evolution conflict, the charge that faith and science are at war must be comprehensively studied and understood. A precipitous gap is present in the literature in reference to the authentic historical relationship of faith and science. If the warfare thesis is simply accepted, then the creationist versus evolutionist conflict affecting science curriculum content cannot be adequately resolved.

This study is designed to help illuminate the intimate connection of faith and science that has existed for more than a millennium (Hannam, 2011; Jaki, 1990; Jaki, 2000; Lindberg, 1992; Stark, 2003) because that connection and its significance to the discipline of education has not been sufficiently studied. The proposed benefits to the discipline of education are centered on diminishing the present conflict between families, religious groups, and the educational community (David & Kenyon, 1993; Larson, 2003; Scheitle, 2011; Zimmerman, 2002). This historical analysis is intended to copiously uncover the facts related to the authentic relationship of faith and science, in the process of answering the proposed Research Questions.

Theoretical Framework

Educators and their students remain in the midst of a conflict over science instruction and curriculum content, which persists as a cultural clash that frequently sets personal religious beliefs, family values, and the educational culture in opposition (Pecora, 2007; Scheitle, 2011; Zimmerman, 2002). This study has been designed to provide a comprehensive account of the historical interaction between faith and science, in the hope that the ongoing cultural discord can be diminished through the realization that science education can only flourish when unencumbered by ideology. The most valuable contribution possible for this research is to provide the discipline of education a comprehensive account of the authentic relationship of faith and science, which can broaden student understanding and assist them in their efforts to discern the difference between empirical science and matters of faith (Skehan & Nelson, 2000).

The proposed theoretical framework that guides this research is grounded in the proposition – expressed by the Bradley Commission on History in Schools – that historical literacy informs and improves educational practice (Brown, 2007). In this case, the value of historical literacy for education is to underscore the need for a comprehensive exploration of the creationist conflict by way of its antecedents, which stretch back through history. History as a hermeneutic for education can foster historical literacy. In this instance, historical literacy concerns the relationship of faith and science, which can enable students and educators alike to form intelligent opinions and make informed decisions concerning the current conflict between particular faith traditions and science (Gilderhus, 2010). Also, the persistent myths encircling the charge that faith and science are at war can be examined through an historical lens. This study is intended to provide a thorough analysis of the history of scientific thinking, as it pertains to faith, to help clarify the myriad of elements that comprise the current conflicts associated with faith and science disrupting public education in 2014.

The role of a theoretical or conceptual framework within research is to guide the research process (Laureate Education, Inc., 2010f) and is often utilized when "something is known conceptually about the phenomenon, but not enough to house a theory" (Miles & Huberman, 1994, p. 17). The theoretical framework employed within this proposed study is grounded in the notion that historical literacy enhances pedagogy and learning (Brown, 2007) by providing the necessary background and context for the comprehensive understanding and interpretation of past events. The research methodology must be theory-driven (Maxwell, 2005) and the theoretical framework that emphasizes the need for historical literacy within education is consistent with the historical approach methodology utilized herein.

The Bradley Commission on History in Schools proposed that historical literacy informs and improves educational practice (Brown, 2007). The commission offered an eloquent explanation of the significance of historical literacy within the educational process:

> Studying history . . . helps [individuals] to develop a sense of 'shared humanity'; to understand themselves and 'otherness,' by learning how they resemble and how they differ from other people, over time and space; to question stereotypes of others, and of themselves; to discern the difference between fact and conjecture; to grasp the complexity of historical cause; to distrust the simple answer and the dismissive explanation; to respect particularity and avoid false analogy; to recognize the abuse of historical 'lessons,' and to weigh the possible consequences of such abuse; to consider that ignorance of the past may make us prisoners of it; to realize that not all problems have solutions; to be prepared for the irrational, the accidental, in human affairs; and to grasp the power of ideas and character in history (para. 8).

Several experts have expressed similar sentiments concerning the need for historical competency. Fukuyama (1989) articulated the necessity for historical understanding as a means to perceive current events in their proper context (as cited in Gilderhus, 2010). In keeping with Fukuyama's sentiments, Albert Shanker (1991), president of the American Federation of Teachers, offered a poignant illustration of historical understanding at work within the debate that took place in the United States Congress over whether or not to wage war against Iraq (as cited in Gilderhus, 2010). Members of Congress filled their arguments with historical references:

> Members talked about Socrates and Abraham Lincoln; the Mexican-American War and the Peloponnesian war…They cited St. Augustine and St. Thomas Aquinas, James Madison and Winston Churchill. Some talked about the appeasement of Hitler at Munich and Mussolini in Ethiopia; others about the Tonkin Gulf resolution that led to our deep entanglement in the Vietnam War (as cited in Gilderhus, 2010, p. 2).

The significance for Shanker (1991) lies in the fact that no one could follow the debate, much less make an informed decision or hold "an intelligent opinion about the wisest course of action…without at least a basic knowledge of history" (Gilderhus, 2010, p. 3). Historical literacy then is much more than a mere shallow mastery of names, dates, and events from the past – it involves the accurate interpretation of history through an educated understanding of historical facts in their proper context (Haider, 2011).

Harvard philosopher George Santana offered a significant utilitarian reason for knowledge of history (Gilderhus, 2010). Santana proposed that people who forget about the past are condemned to repeat it. Educators and researchers seek to make phenomena intelligible through presenting information in an organized, orderly fashion. Random and haphazard events defy comprehension, whereas most academic disciplines seek to accurately depict probable outcomes. The historian who offers cause-and-effect statements affirms "belief in the intelligibility of events in the human world. Things happen for reasons, and inquiring minds can grasp them" (p. 3).

The philosopher Karl R. Popper reasoned that historical literacy is crucial to not only historians, but social scientists as well because both ought to scrutinize the unintentional consequences of deliberate human acts (Gilderhus, 2010). "Historical actors set out to accomplish a set of goals and actually bring about unanticipated or contrary result. Popper wanted students of human affairs to investigate the linkages between intentions and outcomes" (p. 8). The use of theory in research is to draw attention to and help illuminate the research purpose (Maxwell, 2005).

The primary purpose of this study is to fill the gap in the literature concerning the historical relationship of faith and science in order to help ease the cultural conflict confronting so many students and educators in 2014 (Larson, 2003). In keeping with the research objectives, the research questions herein are intended to prompt an in-depth exploration of the past events related to the relationship of faith and science. Thus, for the reason that this study focuses on past, unrepeatable events, the theory based on the proposition that historical literacy informs and improves educational practice is uniquely appropriate for this research (Brown, 2007).

Existing Seminal Research

Several scholars have published historical studies encompassing a myriad of aspects of the creationist versus evolution clash that has its roots the latter half of the 19th century (Larson, 2002; Numbers, 2002), such as: (1) state legislative acts and related court cases (NCSE, 2012; Le Beau, 2007); (2) curriculum responses (David & Kenyon, 1993; Larson, 2003); (3) effects on scientific literacy (Larson, 2002; Davis & Kenyon, 1993; Skehan & Nelson, 2000); and (4) cultural effects on the student population (Scheitle, 2011; Zimmerman, 2002). Many have published works alleging that faith and science are intrinsically opposed (Dawkins, 2006; Draper, 1874; Harris, 2004; Knight & Lomas, 2001; White, 1896). Others have rejected the idea that faith and science are innately opposed (Ecklund & Park, 2009; Jaki, 2000; Schaefer, 2011; Stark, 2003; Walsh, 1915; Wiker, 2011). Scholars have explored how a culture's faith tradition radically shapes their worldview and requisite willingness to explore the workings of nature (Hannam, 2011; Jaki, 1990; Stark, 2003; Woods, 2005). However, a study which comprehensively explores the creationist versus evolution dispute in the context of its historical antecedents and which also examines the underlying, core charge that faith and science are opposed, is apparently absent from the scholarly record.

Doctoral dissertations and master's theses concerning the historical relationship of faith and science and/or the creationist versus Darwinist conflict are remarkably limited. Recent doctoral dissertations related to this issue are particularly scarce, although a few recent scholarly works examined more limited aspects of the creationist phenomenon. For example, Golden (2003) proposed that the federal government actually shaped the current creationist versus evolution controversy through court decisions (p. 148). He proposed court decisions have served to frame the debate from almost the outset of the legal challenges. Golden asserted that considering the creationist versus evolution conflict in terms of opposing scientific theories is shortsighted because it fails to reveal the larger political aspects of the issue.

Golden (2003) went further and asserted that through a series of court decisions beginning in the early 20th century, the United States government laid the foundation that would eventually serve to subordinate Christianity and creationism to the realm of multiculturalism (p. 148). He proposed the federal government essentially undermined and defeated creationism by adopting a revolutionary Darwinist, pragmatist, and secularist position. He suggested that the ultimate banning of creationism from public schools was merely a symptom of the federal government's adoption of a secularist, scientific methodology.

Marrapodi (2012) studied the history of the creationist movement in relation to biblical exegesis and the scientific community's almost immediate acceptance of Darwin's theory. Creationism is the product of a literal interpretation of scripture and originated in direct response to the widespread acceptance of Darwinism by the scientific community (Numbers, 2002). Marrapodi (2012) conducted first-person interviews with key individuals within the creationist movement, which revealed their objectives and strategies in terms of their opposition to any claims of an old earth or evolutionary processes. The Creation Museum in Kentucky was examined in light of the movements' objectives as well. Curiously, Marrapodi concluded that notwithstanding their legal defeats, creationists are winning the cultural struggle between creationism and evolution. He asserted that the creationists have the financial backing, numbers, and energy to bring about a second Reformation in which the widespread acceptance of creationism will be achieved (Marrapodi, 2012).

Becker (2009) noted the long-standing negative attitudes and general distrust the majority of Americans hold toward science and scientific findings. She suggested that new strategies be implemented to enhance the American public's perception of the scientific community and scientific findings. Americans are typically skeptical of many scientific findings that seem counterintuitive to experience. Becker recommended that the long-standing assumption that religion and religious beliefs form a cavernous barrier for the general public that distorts their ability to understand scientific concepts should be reconsidered. Moreover, she asserted that the conflict theory that proposes faith and science are at war, which has been repeated by way of the cannon of three archetypal stories: Galileo's trial, the clash between creationism and Darwinism, and the infamous Scopes “Monkey Trial” of 1925, should be reexamined in light of the theory’s validity and worth in the struggle to bolster the general population’s confidence in science (p. 3). Becker argued that alternative advocacy methods for science are needed because science advocacy centered on the conflict thesis has simply failed to sway the opinion of the American public.

There is an apparent gap in the literature pertaining to the exploration of the creationist versus evolution dispute in the context of its historical antecedents, as well as an examination of the underlying, core charge that faith and science are opposed. Thus, the use of the historical approach methodology and proposed theoretical framework are uniquely justified for this research.

Sources of Information

Data will be collected and analyzed from a variety of source types, including published documents, books, scholarly peer-reviewed journal articles, Church documents, Internet documents, and Internet database documents. It is the case that scholarly, peer-reviewed journal articles play a prominent role in the humanities by providing the most up-to-date related research on various topics. However, historians still primarily publish their latest findings and analysis outside of academic journals, in single authored books (Nieman, Barrett, & Gibbons, 2009). For that reason, the majority of data used within this dissertation will be derived from previously published books.

What is Known Relative to Study

What began as a generally civil debate among intellectuals over Charles Darwin's theory of evolution in the latter half of the 19th century, became increasingly heated through the intervening decades and has since grown into an uncivil and arguably malicious legal confrontation over science curriculum content in American public schools (Ecklund & Park, 2009; NCSE, 2012). Larson (2003) noted "America's first anti-evolution legal action was a 1923 Oklahoma statute prohibiting the inclusion of Darwinism in textbooks distributed by the state" (Evolution in American Ed. Before 1920 section, para. 1). Since then the legal battles have spread through the states and reached the level of the United States Supreme Court. In 1987 the Supreme Court ruled in Edwards v. Aguillard (1987) that the Louisiana law was unconstitutional, which required creation science be taught alongside evolution in public schools on the grounds that the law was specifically intended to advance a particular religion.

The magnitude of the perceived conflict between faith, science, and education is exemplified in the legal challenges over creationism versus evolution (Le Beau, 2007; NCSE, 2001). Although many cases have been decided, others are pending and in the confusion, educators are regularly unsure of their legal standing (NCSE, 1997). For example, some creationists sought to have the teaching of evolution banned on the grounds that it is a religion, but in *Peloza v Capistrano* (1994) the 9th Circuit Federal Appeals Court ruled against their claim:

> The Supreme Court has held unequivocally that while belief in a Divine Creator of the universe is a religious belief, the scientific theory that higher forms of life evolved from lower ones is not (as cited in Scott, 2008, para. 12).

In *McLean vs. Arkansas* (1982) the District court ruled that Creation scientists

> cannot properly describe the methodology used as scientific, if they start with a conclusion and refuse to change it regardless of the evidence developed during the course of the investigation (as cited in Scott, 2008, para. 14).

Moreover, a Federal District Court and its associated Appeals Court ruled in *Freiler v Tangipahoa Board of Education* (1997) that an evolution disclaimer, which singles out evolution from all other scientific concepts for special treatment is not permissible. It is simply not permissible for a public school board to single out evolution from all other scientific propositions by requiring that curriculum material and teachers present evolution as a "theory", as opposed to “fact”. More recently, in *Kitzmiller v. Dover* (2005) a Harrisburg, Pennsylvania Federal District Court ruled that intelligent design is a form of creationism, and therefore, unconstitutional to teach in American public schools (Scott, 2008).

In summary, the courts have ruled that a teacher is permitted to teach religion, such as in comparative religion class, but is not permitted to advance a particular religious belief outside of that context (Scott, 2008). A state legislature, public school district, or public school administration cannot ban the teaching of evolution, require equal time for Creation science, or require a disclaimer stating that evolution is a "theory" and not "fact". Moreover, a public school teacher is not permitted to "freelance" by teaching creationism.

Notwithstanding the various court rulings, in 2008, the State of Louisiana past the Science Education Act, which affirms the classroom teacher's freedom to assist students to analyze and critique various scientific theories, including, but not limited to, evolution, global warming, the origins of life, and human cloning (West, 2008). Proponents of the law propose that the intent of the law is to foster critical thinking and affirm the existence of academic freedom to question even commonly accepted scientific theories. Even so, Louisiana's Science Education Act has many critics, who view the law as a threat to science and a thinly veiled attack on evolution (Louisiana Coalition for Science, 2012). In 2014, the State of Louisiana's House Education Committee rejected House Bill 374 that would have overturned the Science Education Act (Morgan, 2012). Consequently, the debate between creationists and evolutionists is far from settled and classroom teachers and their students have been and remain at the forefront of the conflict.

Unfortunately, the conflict thesis, which asserts faith and science are at odds, affects the discipline of education beyond the ongoing legal struggles over creationism and evolution (Stark, 2003). The persistence of the conflict thesis has spurned several myths that have so permeated Western culture that they are routinely repeated and reaffirmed at all levels of education (Pernoud, 1977/2000; Stark, 2003; Wiker, 2011). Some of the legends often inadvertently and sometimes knowingly advanced by educators and curriculum specialists are as follows:

- science was strenuously hindered by the Medieval Catholic Church (Pernoud, 1977/2000; Stark, 2003; Wiker, 2011; Woods, 2005)
- the Catholic Church was opposed to human dissection (Hannam, 2011; Stark, 2003)
- Columbus and his crew feared they would fall off the edge of the flat Earth on their journey across the ocean (Singham, 2007; Stark 2003)
- Medieval people never knew the time of day because they had not invented clocks yet, hence they were living in the Dark Ages (Pernoud, 1977/2000)
- during the Middle Ages the Catholic Church vigorously obstructed academic freedom (Hannam, 2011; Lindberg, 1992; Stark, 2003; Woods, 2005)
- a pope in the Middle Ages issued an edict that forbade the practice of chemistry (White, 1896)
- Pope Callistus III was given the title "the silly pope," as he was falsely said to have believed Halley’s comet was on a collision course with Earth, so recited

fervent prayers and ordered that all of the church bells in the city be rung in order to change its path (Draper, 1874; Walsh, 1915)

- The Roman Catholic Church did all it could do to suppress heliocentrism and heliocentrism was only saved by the efforts of Protestants following the Reformation (Stark, 2003)
- Galileo was tried, tortured, and/or condemned to death because he said the Earth revolves around the Sun (Stark, 2003; Wiker, 2011; Woods, 2005)
- during the so-called "Dark Ages" of human history, little or no scientific progress occurred, and in fact, the entire period between the fall of the Roman Empire to the beginning of the Renaissance was an interruption to mankind's progress (Hannam, 2011; Lindberg, 1992; Pernoud, 1977/2000; Stark, 2003; Woods, 2005)
- science was unable to advance and prosper until the Protestant Reformation of the 16th century successfully stripped the Catholic Church of its power and influence (Knight & Lomas, 2001; Woods, 2005)

These and other similar legends – all rooted in the conflict thesis – are regularly repeated in modern textbooks (Pernoud, 1977/2000; Singham, 2007; Stark 2003), educational videos (Dorling, 2007), television programs (Public Broadcasting Service, 2002), motion pictures (Sony Pictures, 2006), reproduced in other formats, such as the Internet, and all serve to reinforce and sustain the notion that faith and science are in conflict – even at war (Hannam, 2011; Russell, 2002; Stark, 2003; Wiker, 2011; Wilson, 2002; Woods, 2005). These myths pertaining to faith and science are regularly reiterated at even the highest levels of the scientific establishment. For example, the renowned theoretical physicist, Stephen Hawking, repeated a common example of the warfare myth in his account of Galileo Galilei:

> Galileo's renowned conflict with the Catholic Church was central to his philosophy. He was one of the first to argue that human beings could hope to understand how the world works, and, moreover, that we could do this by observing the real world. Galileo, perhaps more than any other single person, was responsible for the birth of modern science (as cited in Wiker, 2011, p. 36).

The validity of this and similar claims will be analyzed in detail within the succeeding chapters in the hope that a more clear account and interpretation of the meaning of those events will assist educators, as they strive to convey an accurate account of how faith and science interacted through history (Haider, 2011).

Public education has been at the center of the creationist versus Darwinist conflict for close to a century (David & Kenyon, 1993; Larson, 2003), but the problem is not singular in nature (i.e., a debate over science pedagogy and curriculum content). The challenge ultimately extends to the welfare of the students in the desks. Culture justifiably remains a critical consideration in educational curriculum (Zimmerman, 2002). Religious beliefs and scientific perceptions are distinct cultural elements and are significant aspects of a student's experience. In point of fact, the reason the curriculum content debate is so crucial is its potential to negatively affect students in two distinct ways. First, the curriculum content debate can certainly affect their scientific literacy – the "take-home" message (NCSE, 2012). Second, many students perceive the curriculum conflict as a challenge to their personal belief system, as it often challenges their family's values and/or faith tradition (Scheitle, 2011). Although diversity of opinion and respect for opposing views are foundational to scholarship and the educational process, in the midst of the impassioned argument, those engaged in the creationist versus Darwinist conflict have often neglected those principles (Dawkins, 2006; Harris, 2004) and students are simply not oblivious to that fact (Scheitle, 2011).

The ongoing creationist versus Darwinist debate has been characterized as a conflict between science and religion or faith and science (Dawkins, 2006; Harris, 2004; Knight & Lomas, 2001; Stark, 2003; Wiker, 2011). In other words, the charge goes deeper than a mere disagreement over whether or not life evolved through an evolutionary process or not. The more precise allegation by some scholars is that religion truly and deliberately hindered the development of science through the centuries (Dawkins, 2006; Draper, 1874; Harris, 2004; White, 1896). Royal (2006) noted that one powerful strand in contemporary culture persists, which "maintains that the Greeks represent reason and enlightenment…and that Christianity, especially in its Roman Catholic version, is irrational and superstitious" and that "the early Christians suppressed Greek thought and science when they got the upper hand in Rome, leading to the Closing of the Western Mind" (p. 142). Hence, "in this view, the Christian legacy in the West is a history of Dark Ages, Crusades, Inquisitions, opposition to science (e.g., Galileo), religious wars, and various other forms of intolerance" (p. 142).

Since the Age of Enlightenment, many scholars, and more recently, popular writers, have specifically alleged that Christianity obstructed the progress of science

(Stark, 2003; Woods, 2005). Darwinists routinely claim that the current creationism versus evolution debate is simply the latest adaptation of Christianity's long-standing opposition to scientific claims (Dawkins, 2006; Harris, 2004; Royal, 2006; Walsh, 1915). Thus, exploring the historical relationship of faith and science is the first step to analyzing the current controversy in context. The historical antecedents that reveal the intersection of faith and science through time (Jaki, 1990; Stark, 2003) are essential to understanding the current conflict surrounding science curriculum content (David & Kenyon, 1993; Larson, 2003).

A key aspect of the phenomenon under study is how a culture's faith tradition acts as a lens through which that culture views the universe and the world around them (Hannam, 2011; Jaki, 2000). Faith traditions or belief systems within cultures radically shape a peoples' worldview and history is replete with differing belief systems within cultures. Faith, then, necessarily played a crucial role in determining how particular cultures, including Christian Europe, perceived the natural world and natural phenomena, which is the basis of science (Jaki, 1990; Stark, 2003). More specifically, a culture's belief system shapes their worldview to the point of determining whether or not that culture even conceives of the possibility of science (Hannam, 2011; Jaki, 1990).

Creationists have chosen the public schools as the principal battleground for their organized opposition to Darwinism (NCSE, 2012; David & Kenyon, 1993; Larson, 2002; Larson, 2003). The continuing controversy surrounding acceptable science curriculum content and pedagogy for public schools, which is so often obscured by commonly accepted myths and half-truths (David & Kenyon, 1993; Stark, 2003), can be successfully examined using the historical approach methodology and offer a thorough account of the relevant issues to educators and their students (Brown, 2007).

What is Unknown Relative to Study

Several concepts associated with this proposed study are unknown or only known by a small group of experts (Stark, 2003). Continued repetition of now commonly accepted myths surrounding faith and science are unwittingly, but regularly repeated and reinforced within educational circles (Pernoud, 1977/2000; Singham, 2007). How the discipline of science originated and advanced through history is recognized by a relatively small group of experts, but the facts generally escape the balance of the population, including the majority of educators because of the widespread belief that faith and science are in conflict and its accompanying myths (Stark 2003; Woods, 2005). Educators are largely unfamiliar with how theological concepts framed the worldviews of the most prominent world cultures and influenced how those cultures perceived and understood the natural world (Hannam, 2011; Jaki, 1990; Jaki, 2000). Likewise, most are unfamiliar with the theological and sociological origins and aims of the creationist movement, which is effectively disrupting science education in public schools in 2014 (Scharrer, 2011).

Gap in Literature to be Addressed

The long-standing creationist controversy currently disrupting science instruction in public schools has been studied from a variety of different perspectives (David & Kenyon, 1993; Larson, 2002; Larson, 2003; Le Beau, 2007; Numbers, 2002; Skehan & Nelson, 2000). Still, however, education professionals continue to determine the most effective methods to manage the friction between science, religious teachings, and religion's influence on the development of science (Larson, 2003; Pianta et al., 2007). A comprehensive study of the history of scientific development, as it pertains to faith, is not readily available to help illuminate and support that conversation and this study is intended to address that gap in the literature. More precisely, this proposed study is intended to analyze the historical relationship of faith and science, in order to assist educators and students alike to understand the creationist versus Darwinist controversy in context, as well as help separate myth from reality in reference to the authentic relationship of faith and science through history. In this way, the gap in the literature will be addressed in the hopes of forming a solution to the central research problem, which concerns the perceived conflict between faith and science (Dawkins, 2006; Ecklund & Park, 2009; Harris, 2004) that has resulted in a clash of values for many students (Scheitle, 2011; Zimmerman, 2002) and presented many challenges within the discipline of education (Larson, 2002; Skehan & Nelson, 2000).

Moreover, in keeping with the theory which purports that historical literacy informs and improves educational practice (Brown, 2007; Gilderhus, 2010), this controversy can best be understood, managed, or even resolved with an accurate understanding of the historical and proper relationship of faith and science. The myths surrounding the intersection of faith and science that were originally created by various conflict theorists (Stark, 2003; Woods, 2005) and are still unwittingly repeated and reinforced by educators (Lindberg, 1992; Pernoud, 1977/2000; Singham, 2007; Stark, 2003, Wiker, 2011), can best be revealed through accurate historical analysis (Gilderhus, 2010).

General Approach to Historical Research

The historical approach methodology is the most widespread methodology employed to investigate questions related to faith and science because of the nature of the phenomenon (Haider, 2011; Heck, 2004). As noted previously, however, recent dissertations and theses concerning the historical relationship of faith and science and the current controversy surrounding creationism, are surprisingly scarce. However, recent scholarly works by Golden (2003), Marrapodi (2012), and Becker (2009) used the historical approach methodology to explore specific issues related to creationism and science.

Golden (2003) proposed that a transition from the Newtonian to the Darwinian worldview was so widespread that it surpassed the borders of science and transgressed into new perspectives on the role of government. He concluded that a new materialistic framework became increasingly prevalent in society and within governments, including the United States (p. 7). Nonetheless, the creationists' crusade to exclude evolution from science textbooks, which began in earnest early in the 20th century, reflected the Christian conservative grip on American culture (p. 55). He proposed that the United States Supreme Court reinterpreted the principle of separation of church and state, thereby framing how the debate was to be understood and interpreted by the courts from that point forward (p. 148). Golden's historical review included some important antecedents of the creationism versus Darwinism conflict, but did not venture into the question of the historical relationship of faith and science, which is so often misrepresented in contemporary works (Dawkins, 2006; Harris, 2004; Knight & Lomas, 2001).

Marrapodi (2012) set out to explore the roots of "young earth creationism" (p. 6) and is so doing, performed an analysis of how the Book of Genesis was interpreted and understood within early Jewish exegesis (p. 14). Young earth creationism is a remarkably new phenomenon within the Christian landscape, which came about in reaction to the almost immediate widespread acceptance of Darwin's theory of evolution (p. 4). Still, however, most Christians reject young earth creationism in favor of an allegorical interpretation of the creation accounts described in the Book of Genesis (p. 18). First person interviews revealed the creationists' strategies and long-term goals (p. 3) and Marrapodi's conclusion was that the young earth creationists are winning their battle over evolution because of their energy, persistence, numbers, and financial resources (p. 95).

Becker (2009) conducted a review of the historical context of what she referred to as the "three archetypal stories" most frequently cited by conflict theorists, who profess a prevailing "war between science and religion" (p. 3). Her method was to examine the various component elements surrounding each archetypal event before attempting to reconstruct an accurate account of each story. By deconstructing each archetypal story into its component parts, she hoped to compose an accurate narrative that portrayed the events in their historical context. The strength of Becker's work is reflected in the scope of her research sources, which were quite comprehensive (p. 96-100).

The task of the scholar is to gather the most pertinent information related to a particular phenomenon under study, including its antecedents, so as to understand the complexities involved, and then endeavor to explain the various aspects of the phenomenon, in terms of possible new claims, theories, and perspective (Gilderhus, 2010; Haider, 2011; Heck, 2004). Reliable historical research conclusions can be formulated as informal inferences that are firmly grounded in a convergence of antecedent probabilities. In keeping with the norms of the historical methodology and scholarship, the historic relationship of faith and science will be explored and analyzed for the purpose of determining whether the most basic assumption that faith and science are opposed is a justifiable claim. Understanding the authentic relationship of faith and science will provide the foundation for an in-depth exploration of the creationist versus evolution conflict that is deleteriously affecting the discipline of education in 2014.

Answering the proposed Research Questions will provide insight into the actual historical relationship of faith and science through the centuries (Hannam, 2011; Jaki, 1990), including how various theological ideas and faith traditions influenced the development of science (Jaki, 2000; Stark, 2011). Answering the proposed Research Questions will also serve to enlighten the current dispute by providing context to the debate, which is ultimately perceived as a clash between faith and science (Dawkins, 2006; Ecklund & Park, 2009; Harris, 2004; Knight & Lomas, 2001).

The succeeding chapter provides a comprehensive description of the research steps and guidelines to be followed within this dissertation, which were proposed by Busha and Harter (1980), Haider (2011), and Heck (2004), as appropriate for the historical approach methodology. The central research question and sub questions have been rigorously studied by way of: (a) a broad exploration of the most pertinent facts and events related to the intersection of faith and science in history; (b) a consequent preparation of a meaningful description of those facts and events, including the context in which they occurred; and (c) an intentional search for any new or significant concepts that may arise during the data analysis phase.

Chapter 3: Research Method

Introduction

The discipline of education has increasingly appeared at the center of the debate over the proper relationship of faith and science (Larson, 2003). The conflict has progressed from the local school district level to state legislatures and the United States courts (NCSE, 2012; Ferngren, 2002). In many cases, educators and administrators are unsure of what science content they should deem acceptable for instruction (Larson, 2003). Almost by default, students are thrust into the controversy, as science curriculum is debated and introduced that many times is in significant conflict with their personal faith tradition and/or family's values. Essentially, many students witness a cultural clash between three of their closest social groups: their family, faith tradition, and educational environment (Scheitle, 2011; Zimmerman, 2002). A more clear understanding of how science developed as a discipline and what role, if any, faith played in that development may help to diminish the cultural conflict that has continued for more than 150 years.

Where and how science developed as a discipline, as well as whether or not a particular faith tradition played a significant role in that development, is germane to the discussion concerning science curriculum. An important element under investigation concerns discovering the reasons why science flourished in Christian Europe while failing to sustain significant momentum in all other cultures (Jaki, 1990; Woods, 2005). In order to comprehensively explore the research questions, I explored the most notable aspects of the history of scientific discover, along with how various prominent faith traditions understood the physical universe and scientific claims. The historical approach methodology was judged to be the most appropriate methodology for this investigation because it logically derived from the central research problem (Heck, 2004).

The historical approach methodology was uniquely suited for this exploration of the historical relationship of faith and science and how that relationship can inform the conflict currently having a deleterious effect on public education. The myriad of social, religious, cultural, and political considerations, which together influenced the development of science and society's understanding of natural phenomena, can best be explored through an historical lens (Heck, 2004). I examined several sociopolitical and religious factors that converged in Europe and may have provided a fertile environment for sustained scientific achievement over many centuries, but also may have contributed in producing a religious ideology whose members have routinely disregarded any scientific claims contrary to their religious beliefs.

Another distinctive feature of this analysis, which would suggest the appropriateness of the historical methodology, is the fact that this study encompassed several distinctive cultures and spanned several centuries (Heck, 2004). Each of the prominent world cultures that predated and followed the advent of Christian Europe possessed divergent opinions in reference to natural phenomena and the very possibility of science (Hannam, 2011; Jaki, 2000). The significant events that led to the gradual progression toward genuine science involved several cultures and historical eras, which together would suggest the suitability of the historical approach methodology for this study (Heck, 2004).

Chapter 3 provides a detailed description of specifically how this historical research was carried out. To that end, the research design, theoretical framework, justification for selecting and use of the theoretical framework, sampling strategies, data collection strategies, research questions, and research limitations have been described in detail.

Research Design

The qualitative paradigm was deemed the most appropriate paradigm for this research because the type of data necessary to answer the research questions could best be attained within the qualitative approach. The qualitative paradigm ensured breadth and depth through thorough analysis of documents and thick, rich description of phenomena, which were critical to this investigation. The qualitative paradigm is ideal for studying human behavior within the social context in which the behavior occurred and provides an exceptional means of searching for and identifying recurring patterns and themes, including disconfirming positions (Creswell, 2007). Lastly, the qualitative paradigm commonly includes a narrative report that provides research results in which the researcher attempts to describe the phenomenon within its appropriate context (Creswell, 2009). For these reasons, quantitative and mixed-methods approaches were not considered.

The historical approach methodology was the specific qualitative approach employed within this study to answer the research questions. Historical research can be defined as the systematic examination of past events, including the circumstances in which they occurred, for the purpose of better understanding and interpreting the meaning of those events (Haider, 2011). A dynamic examination of past events enables the historical researcher to more accurately interpret the nuances, personalities, and ideas that have influenced history. Rigorous historical research reaches beyond a mere accumulation of facts, dates, and events. Authentic historical research is intended to give meaning to the data for the purpose of better understanding the past and potentially offering counsel for the present and future (Heck, 2004).

Windshuttle (as cited in Heck, 2004) noted that historical research offers a variety of possibilities to the researcher, which range from describing to explaining past events through systematic investigation. The primary objective of historical research is to attempt to uncover the truth about past events. Historical research may uncover evidence that leads to new claims or theories. Historical data are normally accessible to others, which is not usually the case in other qualitative approaches. However, rigorous historical research may provide a synthesis about past events that provides order to what is already known and offer a new perspective on the past. One result of the new perspective or understanding about the past may be a dependable refutation of the evidence for competing claims. When undertaken in a rigorous and scholarly manner, historical research can meaningfully contribute to building a reliable knowledge base concerning the past (Heck, 2004).

Investigation of phenomena over time is one of the defining characteristics of historical analysis (Heck, 2004). Windshuttle (as cited in Heck, 2004) observed that historical analysis, by its nature, focuses on change over time in events that cannot be repeated. The result is that the focus of historical research is on specific circumstances, as opposed to formulation of generalizations about data patterns or predictions concerning the future, as some other designs may be. Consequently, the underlying logic of historical research is markedly different from some other types of designs (Heck, 2004).

The historical approach methodology was appropriate for this project for the following reasons: (a) the pertinent events to be examined transpired over several centuries; (b) it could assist me as the researcher in understanding the background, culture, trends, and implications that arise from the study; and (c) it is particularly appropriate for studying influences on the development and progress of science because it is capable of encompassing origins, theory, growth, personalities, crisis, and the circumstances surrounding each of these phenomena (*Historical Approach*, n.d.).

This research was intended to comprehensively explore the central research question and subquestions through (a) a broad exploration of the most pertinent related facts and events; (b) formulation of a meaningful description of those facts and events, including the appropriate context in which they occurred; and (c) a discovery of any new or significant ideas that may arise through analysis of the data.

Historical research, like all methodologies, entails specific steps or guidelines that should be followed in order to achieve a reliable result (Busha & Harter, 1980):

1. Identify a specific historical problem and the need for certain historical knowledge (i.e., identify the “what” and “why”).
2. Gather as much relevant information about the problem or topic as possible from a variety of primary and secondary sources.

3. If appropriate, form a hypothesis that tentatively explains the relationships between various historical factors.
4. Perform rigorous collection and organization of data and verify the authenticity and veracity of each piece of information, as well as its source(s).
5. Select, organize, and analyze the most pertinent evidence collected and draw conclusions based on the evidence alone.
6. Record conclusions that are supported by the data in an organized, meaningful narrative.

The historical approach is deemed to be the most appropriate methodology for exploration of the central research question and subquestions herein for the reason that each of the above listed criteria are applicable to this study. Comprehensive steps and guidelines for the historical approach methodology proposed by Busha and Harter (1980), Haider (2011), and Heck (2004) will be followed as the general procedures for this study.

Although historical research is not directly scientific in the empirical, experimental sense, comprehensive historical investigation may rightly be described as the science of history. Everything known concerning history is known upon the authority of some individual's testimony or the testimony of a group, but the veracity of the accounts must be determined. The historical researcher is responsible for determining the trustworthiness of each source for the purpose of transmitting authentic testimony. Comprehensive historical research will validly present the historical facts with a view toward causality, as opposed to a mere chronological representation or accounting of events (Haider, 2011).

Theoretical Framework

The theoretical framework for this proposed research is grounded in the existing literature, which is commonly regarded as the strongest support for a theoretical framework (Creswell, 2007; Maxwell, 2005). The Bradley Commission on History in Schools proposed that historical literacy informs and improves educational practice (Brown, 2007). Moreover, because this historical study is comprised of events that began more than millennia ago the literary record is critical to this work. Much has been written concerning the relationship of faith and science, Medieval science, and the historical relationship of Christianity to science. The written accounts concerning the principal actors, along with the most significant events pertaining to the relationship of faith and science within the period of study are the foundation of this historical research.

A research theory that is supported within the existing literature is generally regarded as the strongest framework for a qualitative study (Creswell, 2007; Maxwell, 2005). The theoretical framework of this study is grounded in the literature, which offers unique perspectives of the various events and themes surrounding the phenomenon, as well as a series of explanations of past events and their consequences. In the end, historical literacy improves pedagogy by providing context to past events and offering students a means through which lessons of the past can be applied to contemporary circumstances and challenges (Brown, 2007).

Justification of Theoretical Framework

A study is grounded in a theoretical framework when much is known concerning the phenomena under scrutiny. Conversely, a conceptual framework is developed by a researcher when exploring a largely uncharted theme or issue (Laureate Education, Inc., 2010f). A theoretical framework that is grounded in the existing literature is proposed for this study because much is known concerning where and how science developed, as well as the proposed theory that an inherent conflict exists between faith and science. The literature provides both confirming and disconfirming claims that a conflict exists between faith and science and each will be analyzed in context.

The proposed methodology, research questions, data collection, and data analysis procedures are all aligned and grounded in the theoretical framework provided by the existing literature. The existing literature encompasses: (a) primary sources including writings, documents, and accounts created by persons involved in or contemporaneous with the significant events; (b) secondary sources that offer critical analysis and interpretation after necessary distance in time and involvement from the events (Heck, 2004). Other types of data to be analyzed will include published documents, books, scholarly peer-reviewed journal articles, Church documents, Internet documents, and database documents. Both confirming and disconfirming cases will be analyzed to help ensure research transparency through rigorous scholarship (Haider, 2011).

Alternative Methodology Considered

A second, but rejected methodology considered for this study is a historiography. A historiography is a qualitative approach that is similar to the historical approach methodology, but approaches the issue from a very different perspective. A historiography is the study of how historians have interpreted and reported on the topic or issue over time (Florida State University, n.d.). Historiography has been termed 'the history of the history' on a given topic because it is the study of how the history surrounding an issue has been interpreted, written, and recorded by historians from different eras, places, and cultures. Whereas, the historical approach methodology focuses on both primary and secondary sources, a historiographical review primarily focuses on secondary sources in order to ascertain: (a) what past historians have reported concerning the issue; (b) how historical reporting has changed regarding the issue; and (c) what influenced the various historians and their ideas (Florida State University, n.d.).

Both the historical approach methodology and historiography are suitable approaches for exploring the history of the scientific enterprise. However, the historical approach was judged to be the more appropriate methodology for exploring the specific central research question and subquestions proposed herein. The research questions concern the actual historical events and the specific concern is not exclusive to how historians have interpreted those events through time, but rather, the primary concern is what actually transpired. Moreover, a historiography would likely focus on the now commonly accepted narrative of the conflict theorists, who purport an inherent conflict exists between faith and science. But the veracity of the conflict theory itself is an important element of this proposed study. Although other qualitative, quantitative, and mixed-methods research methodologies offer distinctive advantages and qualities to the researcher, no approach was deemed more suitable than the historical approach methodology to answer the central researcher question and subquestions proposed herein.

Sampling

The proposed sampling strategy herein is directly linked to the bounds of this study in that the sampling helps frame the study within predetermined limits, which will be crucial to streamlining later data analysis (Miles & Huberman, 1994). The historical researcher cannot study everyone, everything, and every event related to a specific phenomenon. By aligning the sampling strategy with the bounds of the study, confidence in the research conclusions can be increased because the study can be much more focused, as opposed to ambiguous and indecisive in nature. Samples in qualitative research are not entirely predetermined, but often evolve during the research process itself, which is very likely to occur during the research phase, as literary sources reveal alternate references (Miles & Huberman, 1994).

Effective research sampling in qualitative research, including historical studies, is essentially a selection process in which the researcher selects confirming and disconfirming cases within the framework provided by the bounds of the study (Miles & Huberman, 1994). Guba and Lincoln (1989) recommended maximum variation sampling, which requires the inclusion of both negative or disconfirming cases, along with confirming cases, thereby providing transparency to the research (as cited in Miles & Huberman, 1994, p. 29). In keeping with these recommendations, great care will be taken during the data collection process to ensure that both primary and secondary sources are selected that represent divergent or dissenting views.

This research study was designed to help ensure a discernible symmetry exists linking the proposed sampling strategy, research questions, data collection procedures, and data analysis strategies (Miles & Huberman, 1994). Confidence in conclusions and generalizability of findings can be greatly enhanced through the research design itself, which must include research component symmetry, wherein properly designed sampling is crucial (p. 34).

Criterion Sampling

Criterion sampling, a more specific form of purposeful sampling, offers tremendous benefits to the historical researcher by enabling the study of only those individuals and events that meet the predetermined criteria (Patton, 2002, p. 238). Weiss (1994) noted that criterion-based sampling enables the researcher to choose participants based on their expertise concerning the subject or the fact that they were a privileged witness to the event or events being explored (as cited in Maxwell, 2005, p. 88). Criterion-based sampling is very fitting for this historical research, which requires the selection of sources that demonstrate expertise and a germane connection to the significant individuals and events related to the development of the scientific enterprise. Criterion sampling will provide the means to identify specific predetermined traits that represent a relationship to the phenomenon of interest, which are intrinsically linked to the bounds of this study (Patton, 2002; Miles & Huberman, 1994). Moreover, criterion-based sampling will also serve to increase the credibility of this study for an academic audience and contribute to generalizability of results (Patton, 2002, p. 240).

Discussion of Sample Size

No specific methodology exists to inform a researcher of how to focus a qualitative study or select a sample size (Patton, 2002). The parameters of a study, including the population and sample size depend on the purpose of the study, the researcher's objectives, the research questions, available resources, expense, and time. Within qualitative research the primary focus of data collection is usually on what is happening to individuals, has happened to individuals within a setting, or how individuals are or were affected by a situation. Consequently, the selected research sampling strategy is largely dependent on the focus of the research and the available units of analysis for study (p. 228).

The primary historical period of concern for this proposed research is from the beginning of the Dark Ages (476 AD) through the end of the Renaissance (1600 AD). However, germane antecedents, particularly concerning cultures that predate the emergence of Christianity, will be explored in light of their contributions and shortcomings related to the development of science. The research population will consist of influential historical figures that actively advanced or hindered scientific development between the fifth and 17th centuries, along with the most significant scientific discoveries within the period. A subset of the accessible population will be sampled, prioritized, and included based on the significance of their contribution (Patton, 2002) to the development and progress of the scientific enterprise. The sampling objective is to include historical contributions drawn from primary and secondary sources that are germane to the stated research questions and objectives. The period of study spans more than a millennium, but the central concern remains how various faith traditions, including creationists, may have advanced or obstructed the scientific enterprise.

The historical researcher should work to uncover a network of sources that are in conversation with one another through cross-referencing sources (Niemann et al., 2009). The cross-referencing of source materials during the data collection process requires researcher flexibility. The bounds of the study are clear, but the need to cross-reference a number of confirming and disconfirming cases may render the establishment of a predetermined sample size untenable. That is, early establishment of a sample size in an historical study may serve to prematurely limit the scope of the project and thereby limit researcher confidence and generalizability of results.

Data Collection

This proposed study includes analysis of both primary and secondary sources pertaining to the central phenomenon. Primary sources will include writings, documents, and accounts created by persons involved in or contemporaneous with the significant events. Primary sources will provide original or first-hand perspective on the noteworthy people and events. Secondary sources will provide critical analysis and interpretation after necessary distance in time and involvement from the events. Secondary sources will be used to build upon and interpret primary sources, as well as later secondary sources created by others (Heck, 2004). However, those who produce secondary sources may have had inaccurate or incomplete information about the events or simply been biased in their analysis. Primary and secondary sources will be sought that represent both confirming and disconfirming cases, as recommended by Guba and Lincoln's (1989) description of maximum variation sampling (as cited in Miles & Huberman, 1994, p. 29).

Manuscripts are another form of primary source that has been defined as the unpublished papers of individuals or organizations (Gant & Hamilton, 2009). Although manuscripts are generally extremely valuable in historical research the vast majorities of the documents available concerning the period of concern for this study have been previously published and are now public record.

Types of data analyzed included published documents, books, scholarly peer-reviewed journal articles, Church documents, Internet documents, and database documents. Scholarly, peer-reviewed journal articles play a prominent role in the humanities and provide the most up-to-date related research on topics. However, historians still primarily publish their new findings and analysis in single authored books – not usually in academic journals (Nieman, Barrett, & Gibbons, 2009) and for this reason most of the data collected herein will be derived from previously published books. All data, including all Church and database documents, to be utilized in the course of this research, are publicly available and together, represent the most appropriate means of answering the research questions herein.

Research Questions

Central Research Question

What additional facts and insights may be learned through a thorough exploration of the historical relationship of faith and science, in light of current challenges confronting educators?

Subquestions

1. What significance, if any, can be attributed to faith in the development of science, during the period between the fall of the Roman Empire through the Renaissance?
2. What importance does the historical origins and progress of science hold in informing the continuing creationist versus Darwinist conflict within education?

Data Coding

Data coding will begin in the initial stages of the data collection process with open coding. Open coding entails the initial identification of concepts deemed significant to the study's purpose (Pitney & Parker, 2002). Open coding includes the process of organizing pertinent data into like categories and subcategories. Open coding will be followed by axial coding, which is the process of relating the respective categories and subcategories to one another in a meaningful manner for the purpose of identifying more precise and comprehensive explanations of the phenomenon under investigation. Axial coding enables the researcher to identify connections between and among the emergent categories and subcategories. Data coding will conclude with the identification of emergent patterns and themes through selective coding.

The research purpose is to arrive at justifiable and reliable conclusions that are logically derived and grounded in the actual events and their causes. Academic rigor demands that historical research be conducted comprehensively and include multiple types of data sources that represent both confirming and disconfirming accounts (Patton, 2002). An organized system of data coding will help ease the organization of the relatively large amount of data required for this historical research and assist in the identification of significant patterns and themes that will contribute to reliable research results.

Data Analysis

On a macro-level, data analysis and the resulting narrative will be carried out from the modernist, as opposed to postmodernist, perspective. For the modernist the overriding concern is the verification and comparison of the evidence surrounding the case (Munslow, 2000). The modernist approach to history has also been described as reconstructionist history. Reconstructionist history denotes a realist, empiricist, referential, objectivized, inferential, and non-ideological approach to history, through which the researcher compiles an account of the events - maintaining distance between observers and observed - and impartially reconstructs the discourse of history. The modernist or reconstructionist historian seeks to formulate interpretations of history through reasoned argument (Fielding & Fielding, 1986). The argument resulting from thorough data analysis should consist of connected statements, comprised of logically valid inferences in which the substantive components are factually correct (p. 19).

Conversely, postmodernist historians reject objectivity in favor of relativism and the result is that postmodern history is no longer an empirical enterprise, but rather, an attempt to describe events without interpretational closure (Munslow, 2000). A prominent theme in the philosophy of postmodernism is the rejection of historical realism and with it the acceptance of the idea that historians are unable to achieve objectivity and thus are incapable of knowing the past (Zagorin, 1999). Postmodernist historians reject representationalism in favor of linguistic turn and the written form of history is considered as important as the past events in creating meaning (Munslow, 2000).

On a micro-level, Koul (1978) proposed that data analysis is the process of organizing and studying the collected data in order to ascertain inherent facts (as cited in Haider, 2011). Direct observation is not possible in historical research because past events simply cannot be repeated at will. Because historical researchers must rely on accounts by those who participated in or observed past events the data must be carefully analyzed in order to accurately interpret true from false and identify irrelevant or misleading information (Haider, 2011). Academic rigor necessitates the need for research transparency. That is, the historical researcher must strive to identify any plausible alternative explanations for the phenomenon under investigation. For the sake of accuracy, facts must be crossed-checked and substantiated through careful corroboration or triangulation of data (Heck, 2004).

Triangulation of data will be performed to safeguard against researcher bias or subjectivity within this study. Hammersley and Atkinson (1983) explained that triangulation involves the comparison of data related to the same phenomenon but deriving from different sources, different points of view, and/or from different participants involved in the setting (as noted in Fielding & Fielding, 1986). When different kinds and sources of data support the same conclusion, confidence in that conclusion is increased. Triangulation helps the researcher to view the material critically, to test it, to identify weaknesses, and to identify the need for additional data. When implemented correctly, triangulation can increase the researcher's confidence so that findings can be better imparted within the results narrative (Fielding & Fielding, 1986). The specific type of triangulation to be utilized within this study is theory triangulation, as described by Denzin (1970), which entails examining the situation from the standpoint of competing theories (as noted in Fielding & Fielding, 1986).

Data Analysis Protocol

Windshuttle (as cited in Heck, 2004)advised that the historical researcher establish a protocol for the purpose of organizing and streamlining the data analysis process. The data analysis protocol proposed for this dissertation will be comprised of the following procedural steps: (1) the preparation of a detailed listing of the various data sources utilized in the course of this study; (2) the creation of a discernible trail showing where each piece of data was found; (3) the description and implementation of a reliable means of coding the research data for ease of retrieval; (4) the performance of both external and internal critical analysis on each data source; (5) the performance of content analysis, which results in a precise description of how each piece of evidence was assessed in reference to its authenticity, relevance, significance, and relationship to emergent patterns and themes; (6) the formulation of a comprehensive narrative that proposes credible conclusions, drawn from the emergent patterns and themes, which are clearly corroborated by the triangulation of data from multiple sources; and (7) a discussion of why alternative theories or explanations of the phenomenon were judged to be implausible, unreliable, or inconsistent with the evidence (Haider, 2011; Heck, 2004).

Step 1: The first stage of data analysis will consist of compiling a list and description of each data source utilized within the course of this research (Heck, 2004). Both primary and secondary sources will be organized, listed, and described for full disclosure. This first stage of data analysis will include both primary and secondary sources that represent both confirming and disconfirming cases, as recommended by Guba and Lincoln's (1989) description of maximum variation sampling (as cited in Miles & Huberman, 1994, p. 29).

Step 2: The second stage of data analysis will include the creation of a clear, discernible trail showing where each source of data was found (Heck, 2004). All primary and secondary sources, including books, scholarly peer-reviewed journal articles, popular articles, court cases, Church documents, academic databases, and Internet sources will be cataloged. Standards of scholarship necessitates that each source be accurately depicted and referenced (Busha & Harter, 1980; Fielding & Fielding, 1986; Haider, 2011; Heck, 2004; Maxwell, 2005; Miles & Huberman, 1994; Munslow, 2000; Patton, 2002; Zagorin, 1999).

Step 3: The central phenomenon to be studied herein concerns discovering the reasons why science flourished in Christian Europe, while failing to sustain significant momentum in all other cultures (Jaki, 1990; Woods, 2005). During the course of this research, both confirming and disconfirming accounts will be uncovered and examined (Patton, 2002). Data coding will be employed during both the data collection and analysis processes, so as to aid in the organization of all relevant evidence. Data coding will assist in organizing large portions of data for ease of retrieval and aid in identifying emerging patters and themes, which can provide context and explanation of individual accounts and events (Miles & Huberman, 1994). The two distinct objectives of data coding within this study will be to, first, label both confirming and disconfirming evidence related to the research questions and, second, aid in identifying and labeling recurring patterns and themes.

Step 4: The data analysis process will include carrying out both external and internal criticism on each data source. External criticism will be applied to ascertain the authenticity and genuineness of each source (Haider, 2011). Gall (2003) noted that external criticism is necessary in order to determine whether or not the claimed origin of the historical document corresponds to its actual origin (as cited in Haider, 2011). Internal criticism will be performed for the purpose of authenticating each source's accuracy, competence, and relative worth to this study. Internal criticism will involve assessing whether or not the author of the document genuinely and honestly reported the events, which necessitates an informed judgment of the motives, including deciphering whether or not any potential bias functioned to distort the author's account of the events (Haider, 2011).

Step 5: Content analysis – the most frequently used method of analyzing historical data – will be performed on each piece of research evidence (Heck, 2004). Content analysis will be conducted on each noteworthy piece of evidence, which will consist of a precise description of its authenticity, relevance, and significance in relation to how it corresponds with the emergent patterns and themes. Content analysis represents a range of different methods of identifying emergent patterns and themes within the data.

Content analysis can proceed from categorizing schemes suggested by theory or previous research, which renders it appropriate for this study, wherein the objective is to research the factors that contributed to the development and progress of science. The veracity of the conflict theory, which purports an inherent conflict exists between faith and science, will be ascertained as a result of content analysis (Dawkins, 2006; Draper, 1874; Ecklund & Park, 2009; Harris, 2004; Knight & Lomas, 2001; White, 1896).

Step 6: Accurately constructing the historical case is reliant upon linking the data back to the study's original purposes and propositions that arose during the course of analysis (Heck, 2004). Windshuttle (as cited in Heck, 2004) observed that the historical researcher must remain flexible during data analysis because unexpected evidence may lead to alternative arguments, interpretations, and conclusions, which were not originally conceived of by the researcher. A credible historical case rests heavily on the inclusion of ample sources and citations, along with a logical discussion of how each source was selected and evaluated (Busha & Harter, 1980; Haider, 2011; Heck, 2004; Munslow, 2000; Zagorin, 1999). Ample citations enable future researchers to access and examine each source, enables the support of conclusions based on the triangulation of data, and also ensures transparency, which itself contributes to reliability. Benham and Heck (1998) emphasized that in order to accurately construct the case; past events must be analyzed in context to achieve a clear understanding, apart from ideological assumptions or presuppositions (as cited in Heck, 2004). Appropriate steps in historical research must be followed because the narrative explaining the likely causal events rests on the logic of a plausible argument that can be evaluated against rival claims. The overriding objective of historical analysis is to accurately construct the historical case without going beyond the data (Busha & Harter, 1980; Haider, 2011; Heck, 2004; Munslow, 2000; Zagorin, 1999). Ultimately, the construction of the historical case rests on logical inferences that are firmly grounded in a convergence of antecedent probabilities (Newman, 1870).

Step 7: The final stage of data analysis will be comprised of a discussion of why alternative theories or explanations of the phenomenon were judged to be implausible or inconsistent with the evidence (Heck, 2004). Alternative explanations and theories will be evaluated using the same criteria specified above in the sixth step of data analysis. An accurate judgment of the veracity of each claim, including alternative theories or explanations of the phenomenon, can be made by evaluating all evidence by the same criterion (Zagorin, 1999).

Transferability, Dependability, and Confirmability

The overarching objective of historical research is to set forth an accurate and credible reconstruction of the historical case (Heck, 2004). To that end, the historical researcher must link the data back to the study's original purposes and propositions by linking emergent themes and patterns that arose during the course of data analysis (Creswell, 2007). Credible transferability of historical research findings have been achieved through extensive analysis and description of the germane historical facts, through which process a credible representation of the historical case has emerged (Heck, 2004).

The research conclusions herein, have been derived from a convergence of antecedent probabilities, which are logically derived from the evidence (as cited in Miles

& Huberman, 1994; Newman, 1870). The result is that the reconstructed historical narrative herein, is the result of arguments derived from data analysis, which enabled the researcher to produce a historical case using connected statements, comprised of logically valid inferences, in which the substantive components are factually correct (Fielding & Fielding, 1986).

Secure Data Retention

In keeping with commonly accepted research protocol, all data, including raw data, software, and procedural details, will be stored for a minimum of five years following the publication of this research (APA, 2010). All data and related materials, as noted herein, will be stored electronically within computer files that are accessible only through a secure password.

Limitations

The historical researcher must remain cognizant of the most prominent inherent weaknesses of the approach (Heck, 2004). The most significant weakness of the historical approach methodology is the possibility of researcher bias skewing the results of the research. A great strength of the historical approach methodology is that it permits substantial researcher creativity, but ironically, creativity can lead to researcher bias through subjectivity. To assist in avoiding researcher bias, the researcher is obligated to include both confirming and disconfirming sources within the research, verify the veracity of each claim through corroboration of accounts, and construct meaningful inferential conclusions that are logically derived from the data. Researcher bias can be minimized, although never completely eliminated, through rigorous adherence to the methodological procedures related to the appropriate sampling strategy, data collection, data coding, and data analysis procedures.

A second disadvantage to historical research is that the process can be very time consuming (Heck, 2004). Both data collection and data analysis can be daunting processes in historical research. The formidable nature of data collection and analysis can be minimized by thoughtfully defining the bounds of the study. The bounds of this study encompass two elements: time and subject matter. Although the study's time period exceeds more than a millennium, the subject itself is narrower and concerns discovering the reasons why science flourished in Christian Europe, but failed to sustain momentum in all other cultures. To assist in streamlining and organizing the process, data has been selected which specifically meet the criteria related to answering the central research question and subquestions. Additionally, computer software was utilized during data collection and analysis and assisted in organization and streamlining the process (Miles & Huberman, 1994).

Ethical Concerns

The primary ethical concern related to this study is closely tied to the methodological limitation, which is the possibility researcher bias can skew the results. The objective is to accurately interpret the historical events in their proper context and this can only be accomplished by faithfully following the research methodology. An array of non-scholarly, popular, even lowbrow sources exists, which contain facts mixed with folklore related to the research topic. The demands of scholarship require that source materials be derived from reliable sources and, of course, academic sources will take great precedence within this study.

A second ethical concern for this research and all academic undertakings is to accurately and honestly convey each author's intended message within each cited source. The demands of academic integrity are such that an honest presentation of each author's ideas is presented in the appropriate context. The principal actors in the events under examination within this study lived many centuries ago, but in order for this research to have significance it must be carried out in a methodical, scholarly manner.

Summary of Chapter 3

Following a general description of the research problem pertaining to education in 2014, which was studied herein, this chapter has provided a detailed description of the historical research process, as applied within the context of this dissertation. Thus, specifics concerning the research design, theoretical framework, justification for selecting and use of the theoretical framework, sampling strategies, data collection strategies, data analysis procedures, research questions, ethical concerns, and limitations of this research, have been communicated herein.

Significance of the Study

In the United States, the debate over the actual or appropriate relationship of faith and science has become increasingly polarized among the contending groups (Dawkins, 2006; Draper, 1874; Harris, 2004; Jaki, 1990; Stark, 2003; White, 1896). The conflict over science course content began shortly following the publication of Charles Darwin's *The Origin of Species* in 1859 and carries on to this day. The argument began at the local public school level, but over time has escalated and advanced to state legislatures and the United States courts (NCSE, 2012; Larson, 2003).

The very public conflict has had deleterious consequences within the discipline of education. Educators are often pressured to teach ideology or religious beliefs in lieu of genuine science content (NCSE, 2012; Larson, 2003; Skehan & Nelson, 2000). Many administrators, curriculum development specialists, and science teachers are simply unsure of what science content is deemed acceptable in their district or state and how best to present that content in the classroom. But the ultimate concern remains the students themselves, who are increasingly witnessing a cultural clash between what very often constitute the three most personal and important cultural elements in their lives: their family's values, their faith tradition, and their educational environment (Pecora, 2007; Scheitle, 2011; Zimmerman, 2002).

Several factors have converged to confuse and blur the public's understanding of the historical relationship of faith and science (Hannam, 2011; Pernoud, 1977/2000; Wiker, 2011; Woods, 2005). The first confusion stems from the myriad of myths that have been disseminated by predisposed individuals since the Age of Enlightenment. In the West, these fables concerning how faith interacted with science have been repeated so often that they have taken root and become "common knowledge." The second confusion exists in the operational definitions used within the long-standing argument over science content in public schools (Stark, 2003).

Because creationists and atheistic Darwinists have engaged in a very public, 150 year-long struggle over public school science content, very often only their two diametrically opposed positions are considered in the public debate (Larsen, 2008; Stark, 2003). That is, textbooks propose either a literal six-day creation account or a Godless formation of the universe and all life forms (Larson, 2003; Davis & Kenyon, 1993; Skehan & Nelson, 2000). Likewise, local school boards and state legislatures limit the debate to the creationist versus atheistic Darwinist paradigm (NCSE, 2012). The difficulty is that not all theists believe in a literal, six-day Creation and not all evolutionists are atheistic Darwinists. This profound polarization in thought simply excludes the majority of theists who believe God may have created through an evolutionary process. Nevertheless, the debate over science curriculum in public schools is regularly reduced to “science versus faith” or “science versus religion” terms (NCSE, 2012; Dawkins, 2006; Draper, 1874; Harris, 2004; Larson, 2003; Stark, 2003; Skehan & Nelson, 2000; White, 1896).

This historical investigation of the various elements of the advancement of science is germane content elements that are regularly neglected. A more clear understanding of history can serve to inform and expand the debate (Brown, 2007). This historical exploration of how science developed, where it developed, where it failed to progress, the factors that enabled or hindered its expansion, and the people who spearheaded its progress, will demonstrate that the evolvement of science immeasurably outstretches the current creationist versus atheistic Darwinist paradigm.

The objective of this historical research is to assist educators as they struggle to understand the proper relationship of faith and science by providing a more clear understanding of how science developed as a discipline. The hope is that this comprehensive study will assist in broadening the understanding of the decision-makers, and thereby, ease the ongoing cultural clash (Pecora, 2007; Scheitle, 2011; Zimmerman, 2002). In the end, students should be taught science in science class – not a religious or philosophical ideology. Significant social change can be attained if educators are freed to teach science apart from ideology and this study is directed toward assisting to achieve that end. Unfortunately, no study is available to inform that conversation and this research is directed toward achieving that end.

In keeping with the desire that this research will contribute to assisting educators better understand the historical relationship of faith and science, as well as the creationist versus Darwinist conflict, the intention is to share this research with the scholarly community. Beyond the publication of this dissertation, it is anticipated that this information will be disseminated, at least in part, through publication of articles within scholarly, peer-reviewed journals, and orally summarized and presented at professional development seminars and conferences, such as, the National Science Teachers Association (NSTA) Conference, Educators Professional Development (EPD) conferences, various statewide science teachers organizations, and other academic venues.

This dissertation is uniquely concerned with exploring the historical antecedents that have led to the problems related to the relationship of faith and science, which educators are confronting in 2014. For more than a century, creationists have insisted that the teaching of evolution be banished from public school curriculum or taught as "a theory" (Answers in Genesis, 2012; Larson, 2003). In response, Darwinists have revived a theory that has its roots in the Age of Enlightenment, which purports faith and science are opposed – even at war (Draper, 1874; Jaki, 2000; Stark, 2003). Several myths and much misinformation is associated with the conflict thesis, which have migrated through time into the public mind and, more significantly, into school curriculum (Pernoud, 1977/2000; Woods, 2005). Chapter 4 below includes an in-depth exploration of the historical relationship of faith and science, which has been undertaken for the purpose of uncovering the antecedents of the issues related to faith and science. The purpose of this research is to provide educators with information that will inform and hopefully lessen the tensions associated with the encircling education in 2014.

Chapter 4: Results

Organization and Presentation of Research

The focus of this study was to thoroughly explore the historical relationship of faith and science, in light of current challenges facing educators. The historical material in this chapter has been organized thematically, although, when practical, presented chronologically for purposes of clarity. A thematic approach was utilized in lieu of a strictly chronological approach because of the necessity to systematically analyze the most significant contributions to the development of science, along with the most noteworthy antecedents, which are best understood in context.

The underlying question that has surfaced in a myriad of different educational contexts is whether faith and science share an important association or are simply mutually exclusive human enterprises or even in a state of endless conflict (Dawkins, 2006; Draper, 1874; Ecklund & Park, 2009; Harris, 2004; Jaki, 1986; White, 1896). Each of the research questions herein addressed different aspects of how faith and science interrelate. Consequently, the facts surrounding where and how science failed to develop and advance may be as important in answering the research questions, as is the history concerning where and how science flourished. Thus, the antecedents rooted in ancient cultures were crucial to this research, insofar as they provided the precursors to the eventual establishment, growth, and progress of science.

The research questions herein have first been comprehensively studied, in keeping with the demands of rigorous historical research. Research findings then follow, which provide context to lessons from history that speak to present-day circumstances and related challenges within education (Brown, 2007). In keeping with the requirements of the historical methodology (Heck, 2004), the theoretical framework for this research was grounded in the existing literature (Maxwell, 2005). The written accounts concerning the most significant events and people pertaining to the relationship of faith and science within the period of study provided the framework for this study.

The methodological process employed to comprehensively explore the research questions herein included three underlying objectives: (a) carry out a broad exploration of the most pertinent related facts and events; (b) formulate a meaningful description of those facts and events, including the appropriate context in which they occurred; and (c) remain cognizant of any new or significant ideas that may arise through analysis of the data.

The historical approach methodology presupposes the observance of specific steps or guidelines necessary to achieve reliable results (Busha & Harter, 1980). The following research sequence was followed herein: (a) identify a specific historical problem and the need for certain historical knowledge; (b) gather as much relevant information about the problem or topic as possible from a variety of primary and secondary sources; (c) if appropriate, form a hypothesis that tentatively explains the relationships between various historical factors; (d) perform rigorous collection and organization of data and verify the authenticity and veracity of each piece of information, as well as its source(s); (e) select, organize, and analyze the most pertinent evidence collected and draw conclusions based on the evidence alone; and (f) record conclusions that are supported by the data in an organized, meaningful narrative.

The definitive objective of this research was to assist educators in their understanding of the historical relationship of faith and science as they struggle to address the claims by some that faith and science are mutually exclusive human initiatives. Currently, many educators and their students find themselves in the midst of a century-and-a-half-long struggle between creationists and Darwinists, concerning the validity or invalidity of the theory of evolution. The long-standing creationists versus Darwinists argument has morphed into a larger question of whether or not faith played any role at all in the development of science. Students, in particular, often discover that their family and/or religious values sharply conflict with the information found in their textbooks (Larson, 2003). As a result, many students are then faced with having to choose between their teacher's values and those of their parents and/or faith tradition. This study was intended to offer information, background, and context to the debate, for the scholarly community, educators, and students alike.

This chapter begins with a survey of the most prominent ancient cultures, comprising their attempts, successes, and failures toward achieving empirical science. After the ancient antecedents have been sufficiently analyzed, arguably two of the most significant developments in the history of science will be examined in detail: the development of the heliocentric model and the theory of evolution. The central research objective was to provide comprehensive answers to the research questions by looking through the lens of history. In the final analysis, historical literacy improves pedagogy by enabling students to understand past events in context and offering insight into ways in which contemporary problems and challenges can be understood (Brown, 2007).

Research Question Objectives

The central research question herein inquired as to additional facts and insights that may be learned through a thorough exploration of the historical relationship of faith and science, in light of current challenges confronting educators. The first subquestion was proposed to discover the significance, if any, that can be attributed to faith in the development of science, during the period between the fall of the Roman Empire through the Renaissance. Lastly, the second subquestion herein was proposed for the purpose of discovering what importance the historical origins and progress of science hold in informing the continuing creationist versus Darwinist conflict within education.

Data Collection and Reporting

This study addressed the research questions through analysis of both primary and secondary sources (Heck, 2004; Miles & Huberman, 1994). Primary sources included writings, documents, and accounts created by persons involved in or contemporaneous with the significant events under study. Primary sources provided valuable, first-hand accounts of the noteworthy people and events. Secondary sources provided this study considerable breadth and depth by way of critical analysis and interpretation of the events, after necessary distance in time from involvement.

Secondary sources were used to build upon and interpret primary sources, as well as later secondary sources generated by others (Heck, 2004). However, because of the possibility that secondary source authors may have had access to inaccurate or incomplete information or simply been biased in their analysis, I continually cross-referenced facts by means of triangulation of data. In keeping with Guba and Lincoln's (as cited in Miles & Huberman, 1994) description of maximum variation sampling, primary and secondary sources were collected that reflected both confirming and disconfirming opinions, which were evaluated on their individual merits, as well as whether or not they were able to be corroborated through a convergence of evidence (p. 29).

Types of data referenced herein include published documents, books, scholarly peer-reviewed journal articles, Church documents, Internet documents, and database documents. Although scholarly, peer-reviewed journal articles play an important role in the humanities insofar as they provide the most up-to-date research on a wide range of topics, historians have still primarily published their work in single-authored books, not usually in academic journals (Nieman, Barrett, & Gibbons, 2009). Accordingly, the majority of data presented and analyzed herein were derived from previously published books. Also, all data that were utilized in the course of this research, including all Church and database documents, are publicly available, and are thus, easily accessible for future research purposes.

Data Organization and Tracking Procedures

Books that were available in e-book form were most preferred, as they are automatically electronically stored, organized, and easily searchable. Whenever hard copy, printed books were quoted or referred to within this work, they were simply included in the continually developing reference list and cited in the document. When available for download, electronically available articles were, when available for download, stored alphabetically in a dedicated computer file. When not available for download, electronically available articles were simply accessed via their corresponding DOI number or URL address. Likewise, database documents, when available for download, were saved in a computer file for future access. Database documents were accessed via their corresponding URL address when not available for download.

The fact that this dissertation was organized thematically was of great assistance in storing and retrieving relevant information, regardless of the data source type. Thus, for example, several times during the course of research, a single book, article, or document was relevant to several different sections of this study. A word processing document was used in rough draft form, as a platform or staging area to hold all potentially pertinent information (either confirming or disconfirming), including: ideas, perceptions, statements, or direct quotes, along with requisite titles, page numbers, DOI numbers, and URL links.

The document used for staging all potentially useful information was also organized thematically, which greatly enhanced data organization and retrieval. Consequently, following data collection and analysis, the writing process itself included (a) transferring ideas from the data staging document into particular headings or themes in rough draft form; (b) development of second draft, wherein pertinent information was organized more efficiently within the dissertation template; and (c) writing appropriate revisions within the final document. Thus, the writing process was intimately connected to the data collection and retrieval processes. As more data were collected and analyzed during the course of the research process, recurring themes became apparent. Recurring themes were recorded, along with all relevant retrieval information for later use.

A draft form of the reference list was continually revised and developed during the course of this research cycle. In the course of data collection, whenever any thought, idea, insight, or quote was used from any new source, irrespective of the type of source, that source was immediately added to the draft reference list in the appropriate format. The result was that throughout the entire research sequence, the reference list developed in an ordered manner.

Treating of Emergent Themes and Discrepant Cases

Identifiable themes began to emerge during the course of data analysis, which pertain to various aspects of the historical relationship of faith and science. When major themes became apparent in the course of research, the data organization and tracking procedures that had been implemented enabled the recognition and recording of major themes a simple matter. For example, very early in the research process, major themes began to emerge, such as: the importance of worldview within cultures; the power of worldviews that are shaped by religious beliefs; the connection between a civilization's theological beliefs and their willingness or desire to investigate the workings of nature; similarities between ancient civilizations in terms of worldview and nature; the Christian worldview and nature, etc.

As the study progressed, it became clear that within this research the nature of discrepant cases concerned claims that countered or challenged the prevailing themes. For example, during data collection and analysis it became clear that science originated, took root, and then flourished in Christian Europe (Hess & Allen, 2008; Jaki, 2000; Stark, 2003; Woods, 2005). More specifically, the empirical scientific methodology itself was formulated by Christian thinkers and as a result, the first scientists were Christian intellectuals, specifically Catholic priests. Discrepant cases, then, concern claims to the contrary. For example, the claim that the Catholic Church of the Middle Ages sought to hinder or suppress science was analyzed herein (Dawkins, 2006; Draper, 1874; Harris, 2004), as well as the claim that many highly developed ancient civilizations, such as, ancient Egypt and ancient China developed empirical science (Jaki, 1990; Stark, 2003). These and similar discrepant cases emerged during the course of data collection and analysis and were analyzed herein, using the historical methodology described above (Heck, 2004; Miles & Huberman, 1994).

Implementation and Adjustments to Research Procedures

Credibility, transferability, dependability, and confirmability of research findings were accomplished with no procedural adjustments, in keeping with the research procedures, as described in chapter 3 above. The credible transferability of findings has been achieved through extensive analysis and description of the germane historical facts, through which process a credible representation of the historical case has emerged (Heck, 2004). Research conclusions have been derived from a convergence of antecedent probabilities, logically derived from the evidence (as cited in Miles & Huberman, 1994; Newman, 1870). The result is that the reconstructed historical narrative herein, is the result of arguments derived from data analysis, by which the historical case is presented using connected statements, comprised of logically valid inferences, in which the substantive components are factually correct (Fielding & Fielding, 1986).

Evidence of Quality

Evidence of quality, as indicated previously in Chapter 3, is intrinsically linked to adhering to an established protocol within the accepted norms of the historical approach methodology. In this case, three of the seven steps proposed by Windshuttle (as cited in Heck, 2004) were instrumental in helping facilitate meaningful evidence of research quality. Step (4) required that both external and internal critical analysis be performed on each data source used in the research. External analysis was performed on each data source to ensure that the account or evidence given is authentic, genuine, and/or valid. Internal analysis was also performed on each data source, which was a determination of whether or not the author was confident, honest, and unbiased in their reporting. Internal analysis was largely accomplished through careful triangulation of data, wherein each piece of evidence was corroborated by multiple sources, which, in effect, helped ensure an unbiased accounting. Internal analysis or triangulation of data played an important role in the development of this research.

Step (6), as described by Windshuttle (as cited in Heck, 2004) required that a comprehensive narrative be formulated that is supported by credible conclusions, which rationally emanate from the evidence. Thus, the research conclusions were derived from a convergence of antecedent probabilities, which were logically derived from the evidence (as cited in Miles & Huberman, 1994; Newman, 1870). Step (7) helped ensure evidence of quality, as alternative theories and explanations of particular phenomena were evaluated in terms of plausibility, reliability, and whether or not they were consistent with the balance of the existing evidence.

The quality of research was enhanced through the processes of striving to identify plausible alternative explanations, confirm accuracy of facts, and the cross-checking and triangulation of data sources (Heck, 2004). In this case, the specific means of triangulation implemented was theory triangulation, as described by Denzin (1970) and cited in Fielding & Fielding (1986). Theory triangulation entails examining the various accounts from the standpoint of competing theories, which was particularly appropriate in light of the research questions under examination herein.

Ancient Achievements and Shortcomings

A critical element of this research pertains to how an unbridled emanationism and pantheism effectively barred any recourse to logic and consistency in worldview, and thus, failed to provide fertile soil for authentic scientific enquiry (Jaki, 2000). The rise of genuine science is more than a systematic description of isolated people and events (Heck, 2004) and is better understood in light of two significant factors: (1) the history of early cultures who failed to initiate and sustain scientific enquiry; and (2) the eventual rise of science on the European continent during the Higher Middle Ages (Jaki, 1990; Jaki, 2000; Stark, 2003; Woods, 2005).

The central research question herein necessitated a thorough exploration of the historical relationship of faith and science, as it pertains to current challenges facing educators. Accordingly, significant efforts toward achieving science by the most notable and advanced civilizations in history– even those that ultimately failed – are germane to the central research question because they further illuminate the historical link between faith and the quest for science. For that reason, ancient efforts at understanding the natural world and their corresponding attempts to explain natural phenomena were a rational starting point for this enquiry.

Ancient Civilizations

From a historical point of view, ancient civilizations are usually considered to span from the earliest recorded time and extending to the time of the fall of the Western Roman Empire in 476 A.D. (Ancient, 2013). However, historical periods are difficult to define and categorize, as designations are always created after the fact by scholars who did not live during the era. Thus, for the purposes of this dissertation, "ancient civilizations" will denote all pre-Christian (i.e., B.C.) societies. Also, the terms "ancient civilization" and "ancient culture" will be used interchangeably.

One might suppose that the rise of science is a normal feature of cultural progress, which always accompanies the growth of civilizations (Stark, 2003). In truth, however, the majority of quite sophisticated cultures never produced communities of scientists, systematic theories, or embarked on systematic empirical observations of nature (Jaki, 1990; Jaki, 2000; Woods, 2005; Walsh, 1915). It is indisputable that ancient culture made ingenious strides in industry and sometimes careful observation of the natural world. But equally noteworthy, in light of their achievements, is the inescapable fact that each of the most prominent ancient world cultures failed to sustain scientific progress.

Succeeding generations repeatedly failed to follow up on what were many times significant discoveries (Jaki, 1990; Woods, 2005; Walsh, 1915). For example, the ancient Egyptians developed hieroglyphics in the form of representative symbols for verbal communications. But they apparently never conceived of a similar breakthrough related to symbolizing quantities, measurements, and calculations, which would have been much easier than symbolizing language communications (Jaki, 2000). More to the point, succeeding generations continually failed to even comprehend the significance of many important discoveries (Jaki, 1990; Stark, 2003; Woods, 2005).

Ancient Egypt, India, China, and Greece each progressed toward science and technology to a discernible point, but then in each case, their advancement – seemingly inexplicably – halted (Jaki, 2000; Stark, 2003; Woods, 2005). The ancient cultures of Egypt, India, and China are most informative because they each left readily traceable records detailing their industrious achievements, and, significantly, there is little evidence that they were greatly influenced by one another (Jaki, 1990). Thus, it is instructive that each of these ancient cultures made independent strides in science, but then experienced a distinct cessation of progress. The same is true of every other ancient civilization of record – all failed to produce and sustain genuine science (Jaki, 2000; Stark, 2003; Woods, 2005) and this research is directed toward discerning the reasons for their respective inability to envision and carry out authentic empirical investigation of nature.

Analysis of the efforts, successes, and shortcomings of the most prominent ancient world cultures, concerning their efforts toward developing authentic science, reveals that every ancient civilization held a mystical – non-rational – perception of the natural world (Jaki, 1990). This pervasive, non-rational sense of nature was widely disseminated among the ancients and was grounded in their pagan and pantheistic religious beliefs, which inhibited any serious contemplation of the natural world and natural phenomena. Thus, in keeping with the intention of the central research question herein, the following section surveyed the scientific efforts of arguably the most intellectually influential ancient civilizations in history: Egypt, India, China, and Greece.

Ancient Egypt

Egyptian hieroglyphics, although highly praised for their inventiveness, are also representative of an apparent intellectual oversight. Hieroglyphics represent forms of symbol-making in which verbal communications are visualized (Jaki, 2000). It has become an academic cliché to praise Egyptian hieroglyphics as a great intellectual achievement of the ancient world or even the most highly developed form of phonetic writing ever produced. Yet, it is revealing that the ancient Egyptians failed to achieve a similar breakthrough in symbolizing quantities, measurements, and calculations, which would have been easier than representing language communications (p. 23).

Empirical science requires careful observation and precise measurements of quantities, time, and speed (Spitzer, 2010). Consequently, making predictions and developing hypotheses concerning various phenomena most often requires extensive use of mathematics. The ancient Egyptians used mathematics, but for all of their industrious achievements during the course of their 3000 year history, they never surpassed a practical knowledge of mathematics (Jaki, 2000, p. 69). For example, although advanced mathematics in the form of algebra, advanced geometry, or trigonometry would have been of great benefit in the construction of the pyramids, they were built using only the most rudimentary forms of calculation (Jaki, 2000).

The ancient Greeks reported that they believed mathematics originated in Egypt and Mesopotamia (Lindberg, 1992). Yet, the outstanding feature of Egyptian mathematics was its intensely practical nature, never having evolved to a pure speculative nature (Jaki, 1990). Neugebauer (1926) noted the absence of any abstract use of numbers or generalized statements in Egyptian mathematics, as well as any form of algebra (as cited in Jaki, 1990, p. 69). In addition to surveying and engineering, ancient Egyptian arithmetic was used in accounting of large quantities of goods, in the absence of currency. Egyptian geometry was oriented toward solving practical problems for engineers, surveyors, and builders, but there is no evidence that the Egyptians utilized general formulas for their calculations. Rather, records reveal that they resorted to trial and error to solve mathematical difficulties. Likewise, Egyptian units of measurement exemplified an unsystematic character (p. 70)

In order to properly distribute vast quantities of grain and other basic commodities among their people, ancient Egyptians had to rely on an arduous system of stock-taking and bookkeeping that resulted in a colossal task in view of their rudimentary methods of calculation (Jaki, 1990). This disparity between tasks and means endured throughout the whole of Egyptian history. Vercoutter (1957) concluded that “the burdens of bookkeeping kept Egyptian arithmetic in a bondage from which it never managed to liberate itself” (as cited in Jaki, 1990, p. 68). The state of Egyptian arithmetic gives meaning to Plato’s statement that Egypt was a nation of shopkeepers (Jaki, 1990).

Egyptian Astronomy

Although Egyptian astronomy primarily served religious purposes, in keeping with other Egyptian endeavors, it served a very practical purpose as well (Jaki, 1990). The vast majority of Egyptian people were involved in agriculture and the Nile provided fertile soil by flooding during the rainy season. Thus, accurately predicting and anticipating the onset of the rainy season was crucial to the Egyptian people and economy. Egyptian astronomers responded by calculating a twelve month solar year, divided into three periods of ten days each, which provided an accurate means to anticipate the seasons (Lindberg, 1992). But curiously, throughout much of their long history, no efforts were made to coordinate their three calendars (i.e., two lunar and one civil). In fact, the crowning ritual of the pharaohs contained an oath that forbade any attempt to revise or reform the calendars (p. 71).

Egyptian Medicine

Egyptian attempts at medicine included pharmaceuticals derived from plants and animals, as well as surgery, but the marked characteristic of Egyptian medicine was its co-mingling with religious symbolism and divination (Jaki, 1990; Lindberg, 1992). The ultimate aim of the treatment was always to rid the body of the evil spirit causing the illness by administering incantations and rituals. Although Egyptian physicians utilized a wide variety of medicinal remedies the result was most often that the antidote administered was worse than the disease itself (Jaki, 2000). Repulsive arrays of indigestible substances were fed to the sick for the reason that an animistic force or evil spirit would rather leave the body than endure nauseating smells and food. Records reveal that the ancient Egyptians never appear to have comprehended or even speculated that illnesses could be brought about by natural causes (Jaki, 1990).

Eternal Cycles

The Egyptians possessed a deep-seated cyclical outlook in reference to time and events, which effectively inhibited scientific and historical reflections (Jaki, 1990). They assiduousness recorded data, but had practically no appreciation of history. Their failure to apprehend the need or even possibility of scientific inquiry and historical reflection is not an accident, but characteristic of their animistic, pantheistic worldview that attributes all causality to unpredictable supernatural influences (Jaki, 2000; Woods, 2005).

Scientific inquiry and historical study both require causal and rationally confident probing into the space-time matrix – a space-time matrix in which physical and human events occur in a singular moment and run their irrevocable courses (Hess & Allen, 2008; Jaki, 1990; Jaki, 2000). Scientific enquiry presupposes that events are not returning on themselves in an eternally cyclical nature, but occur in a singular, measurable moment (Woods, 2005). Presupposing that all of nature is caught up in a succession of eternally repeatable events and that an array of gods and spirits influences and controls every facet of nature, suppresses one's ability to conceive of a comprehensible, rational universe governed by natural laws (Jaki, 1990; Woods, 2005).

Summary

The ancient Egyptians made breakthroughs in practical forms of mathematics, astronomy, agricultural practices, writing, and medicine, but left evidence of inexplicable gaps in their achievements (Hess & Allen, 2008; Jaki, 1990; Lindberg, 1992). It does not suffice to claim that Egyptians failed to develop genuine science because they simply did not feel the need for it. That line of argument would suggest that they were so insensitive to their own well-being that they simply settled for a medical art that routinely caused more harm than good. Countless Egyptian mummies exhibit classic tooth decay that infected much of their population, which first devastated their teeth and then progressed to the point of rotting away part of their jawbone. Yet, there is no evidence that they ever extracted rotting teeth, which would undoubtedly have saved many lives (Egyptian Medicine, 2010).

Perplexing Egyptian shortcomings are evidenced in their: (a) inability to envision pulleys and wheels; (b) failure to develop consistently accurate means of surveying for building projects; (c) refusal to synthesize their three calendar systems; (d) inability to develop curative medicine; (e) failure to achieve a breakthrough involving quantities, measurements, and calculations to match their achievement in hieroglyphics; and (f) failure to perceive cause-and-effect in relation to historical events and natural phenomena (Jaki, 2000; Lindberg, 1992).

After conducting an exhaustive study of ancient Egypt, Engelbach (1923) concluded "there was little radical progress from the Third Dynasty until nearly Ptolemaic times" (as cited in Jaki, 1990, p. 78). That is, one of the foremost scholars on the Egyptian civilization concluded that they essentially remained technologically and industrially stagnant from about 2650 BC to 330 BC – more than two millennia.

Ancient Egypt, like every pagan culture of record, achieved several impressive, but disconnected insights, along with numerous practical skills, while at the same time holding an array of confusing and contradictory beliefs (Jaki, 1990). Raising all material substance and natural phenomena to divine status effectively obstructed the Egyptians' desire to investigate natural phenomena for any reason other than religious motives (Jaki, 1990; Woods, 2005).

Ancient India

Two factors converged in ancient India that effectively obstructed their desire to investigate the natural world and both factors were intricately connected to, or rather, resulted from their distinct Hindu and Buddhist faith traditions (Jaki, 1990). The first factor concerns the deep-seated desire of the Hindu and Buddhist to escape reality and the cares of this world, so as to reach a state of Nirvana – a state of disinterested wisdom and compassion that is the "Ultimate Reality" or "Supreme State" (Casewit, 2011, p. 25). A people that are obsessed with leaving the material world behind to retreat to a consciousness devoid of reason are not positioned to achieve sustained advancement in the investigation of the material world (Woods, 2005). The second factor that effectively impeded their desire to investigate the physical world is related to their fascination with cyclical returns or infinitely repeating cycles of birth-life-death and rebirth. The difficulty is that a culture that presupposes that everything in nature will endlessly repeat and return upon itself, does not foresee any advantage to understanding the workings of nature (Hannam, 2011; Jaki, 1990; Woods, 2005).

Although Indian culture made an impressive contribution to science by originating the decimal system and notation, scholars of Indian culture have been frustrated in their inability to explain India's failure to capitalize on their greatest contribution to science (Jaki, 1990; Lindberg, 1992). Although the decimal system and notation were devised in ancient India, wholly inadequate dating of Indian manuscripts has prohibited scholars from even identifying the century in they were developed. Thus far, the most accurate estimated date ascribed to the Indian decimal and notation system falls between the fourth and seventh centuries. The decimal system and notation are undoubtedly India's most important single contribution to science, insofar as the development of scientific methods would have been considerably delayed had scholars of the Middle Ages had to rely on cumbersome Roman numerals. Although the Indian decimal system needed further precision for systematic, quantitative scientific inquiry, it represents an extremely significant contribution to what would later become an explosion of scientific advancement. However, not only did India fail to follow up on their greatest contribution to science, they also left no record as to how, where, or for what purpose the first decimal system was produced (Plofker, 2008).

Another consequence of Hindu and Buddhist beliefs that place no importance on the rationality and order of the universe (Capra, n.d.), is revealed in the Indian fascination with astrology that has endured for three millennia and remains a deep-seated belief in contemporary Indian culture (Jaki, 2000). For example, the January 6, 1983 addition of the *International Herald Tribune* recorded that high government officials in India hosted a 1982 symposium for astrologers to advise the government (as cited in Jaki, 2000, p. 30). In the end, ancient India's religious beliefs were characteristic of Eastern mysticism, Buddhism, and Hinduism, which are "interested in intuitive wisdom, rather than in rational knowledge" (Capra, n.d., para. 1), and thus, did not provide sufficient motivation to investigate the workings of nature.

Ancient China

Ancient China must be considered in any serious effort to explore the historical relationship of faith and science, as China is exemplary of a very early, advanced civilization that was immersed in pantheism and the notion of eternally recurring cycles of birth-life-death and rebirth (Jaki, 1990). Like all other early civilizations of record, China obtained very impressive advancements in industry and practical knowledge, but their advancements, like their counterparts in the ancient world, ceased and were never pursued further and improved upon (Stark, 2003).

Many scholars, as is evidenced herein, have been baffled as to why ancient China failed to develop science, as China possessed all of the necessary resources for the development of science several centuries before the Western world (Stark, 2003). Those scholars perplexed by China's initial achievements that were followed by a conspicuous lack of progress in understanding natural phenomena, did not consider or simply overlooked the essential connection between faith and science. China's worldview, which was shaped by their ancient faith traditions, is also intricately linked to their failure to embark on an earnest investigation of physical reality (Woods, 2005) and this connection must be seriously considered within the context of this research.

The early 20th century scholar and historian, Bertrand Russell, lectured in China for a year and was baffled by as to why the Chinese lacked science (Stark, 2003). He noted that in light of the fact that China was culturally sophisticated long before Europe, they should have developed science ages before the Europeans. Russell remarked: "Although Chinese civilization has hitherto been deficient in science, it never contained anything hostile to science, and therefore the spread of scientific knowledge encounters no such obstacles as the Church put in its way in Europe" (as cited in Stark, 2003, p. 150). In point of fact, Russell expressed great confidence that because the Chinese were not obstructed by the Church, Chinese science would quickly surpass Western science. Russell, a self-professed atheist, never considered the possibility that China's particular theological ideas may have impeded their desire to pursue science (Stark, 2003).

Through the centuries the Chinese people have worshiped an array of different gods, but the Chinese intellectual class has long taken pride in their "godless" religions, wherein the supernatural is perceived as an impersonal, remote essence, or, more precisely, governing principles (Stark, 2003). "The Tao is an example of an essence; Yin and Yang represent a principal" (p. 150). The Chinese cosmology, which resulted from their Eastern form of pantheism, was one which precluded the possibility of a personal Being responsible for creation. Impersonal essences and principles do not create anything or provide governing laws to anything, much less create a universe. Hence, Chinese sages proclaimed the universe simply exists and has always existed (Stark, 2003). Moreover, the Chinese, like most other ancient cultures of record, were staunch believers in an eternal, cyclical, ever repeating universe (i.e., a universe in which every material thing, including individual life forms, as well as every action, are literally repeated over and over again) (Hess & Allen, 2008; Jaki, 1990; Woods, 2005).

To the Chinese mind, there was simply no reason to suppose that this constantly recurring universe functions according to rational laws, "or that it could be comprehended in physical rather than mystical terms" (Stark, 2003, p. 151). The Chinese were content pursuing enlightenment and were not particularly concerned with discovering explanations. As late as the mid-20th century, the distinguished Chinese scholar, Yu-Lan Fung, attempted to explain what he perceived to be the backwardness of China, which he traced to the fact that China had neither developed science nor adopted the vigorous cultivation of science (Jaki, 1990). Fung's comments reveal a subtle air of defiance, "China has no science, because according to her own standard of value she does not need any...China has not discovered the scientific method, because Chinese thought started from mind, and from one's own mind" (as cited in Jaki, 1990, p. 25).

Fung's comment regarding Chinese thought starting from the individual's mind is a reference to the predominant influence of Confucianism and Taoism in Chinese culture, which markedly informed attitudes toward nature and science among the Chinese intellectual class (Lu, 2011). Confucianism emphasizes an inward-looking, introspective way of life, centered on ethical living that unambiguously disregards concern for physical reality. Taoism, emphasizes love and respect of nature, but emphasizes that nature should be completely left alone and any consequences of nature should simply be accepted. Taoism also teaches that the external world is far too complex to be understood through analysis, examination, observation, or mathematical examination (p. 216). Needham (1979) discerned that taken together, Confucianism and Taoism imparted a *laissez-faire* mindset concerning the natural world that inhibited the Chinese desire to investigate nature.

A few examples will suffice to demonstrate China's consistent failure to recognize the full extent and potential of their discoveries. The Chinese had rockets for several centuries, but failed to investigate trajectories or explore the regularities of free-falling objects, which are fundamental to the study and advancement of rocketry (Jaki, 1990). The Chinese discovered an exploding powder, but only used it as a novelty in firecrackers (Hannam, 2011). Whereas, upon seeing a firecracker explode for the first time, the 13th century Franciscan, Roger Bacon, immediately perceived its implications for weapons and even engines of the future. In a precursor to modern chemistry, Europeans soon analyzed the chemical composition of the exploding powder and put it to use in cannons. Magnetism had long been recognized by the ancient Chinese, but for centuries had only been used in geomancy (i.e., a form of divination), *feng shui* (i.e., the belief that energy flow is governed by spatial arrangement), and later as a novelty, wherein a needle floating in liquid always pointed north (Magnetic Lab, 2013). But within a few decades of the missionaries return home with the magnetic needle, ships all across the European continent were equipped with navigational compasses. As a result of the Chinese failure to foresee the implications of the compass beyond a novelty for children, the Chinese never produced a Vasco da Gama, Columbus, or others who circumnavigated the globe (Hannam, 2011; Jaki, 1990; Stark, 2003).

The Chinese were only familiar with the basic rudiments of geometry and conceived of a disk shaped Earth. Jaki (2000) asserted, "…recognition by the Chinese of the sphericity of the earth was fainthearted at best…One would search in vain in the writings of medieval Chinese astronomers and cartographers for numerical estimates of the radius and circumference of the earth…" (p. 32). By contrast, the ancient Greeks calculated the circumference of the Earth with incredible accuracy. Chinese cosmology, like most ancient cosmologies, was cyclical in nature and notably lacking of any recognition of cause-and-effect, which is, of course, foundational to the pursuit of science. The conviction that everything is cyclical obstructed the Chinese awareness of cause-and-effect in nature. For example, in place of cause-and-effect the ancient Chinese conceived of manifestations of nature and saw no importance as to the order in which natural manifestations appeared. The Chinese astronomer, Hu Hsi, exemplified the nature of the Chinese cosmology when he explained the periods of the sun, moon, and planets as analogous to animals that go in and out of their hiding places (Jaki, 1990).

Eastern pantheism, informed by Taoist admonitions against investigating nature (Lu, 2011), combined to prevent the Chinese from recognizing the significance of essential elements of science, such as, measure, quantity, frequency, and order of magnitude (Jaki, 1990). In lieu of perceiving natural phenomena as observable and quantifiable, the ancient Chinese saw only a mass of concrete signs that are best chronicled by the historian, as opposed to the physicist. The result of the Chinese outlook was that history took the place of science in the ancient Chinese world (Granet, as cited in Jaki, 1990, p. 35).

The depth at which Confucian and Taoist beliefs influenced the Chinese mind was still explicit in the 16th century, as the most prominent Chinese intellectual, Wang Yang-Ming, expressed marked resignation about the utter uselessness of trying to investigate nature and the literal headaches that accompany such efforts (Jaki, 1990). He recounted how his friend had tried for three consecutive days to uncover the composite structure of bamboos, but the only result was that he was overcome with mental exhaustion. Then

Yang-Ming took his turn and attempted the same study for seven days running, but also with no success. He described how he not only failed, but became ill from the excessively burdensome mental exercise. Yang-Ming wrote, “thus we both sighed and concluded that we could not be either sages or men of virtue, lacking the great strength required for carrying on the investigation of things,” and the spark of scientific enquiry they displayed, however fleetingly, ended abruptly as Wang concluded:

> When, while living among the savage tribes for three years, I clearly saw through this idea [the problem of the investigation of things], I knew that there was really no one who could investigate the things under heaven. The task of investigating things can only be carried out in and with reference to one's body and mind (as cited in Jaki, 1990, pp. 35-36).

Lang (1997) dismissed the notion that religious beliefs prohibited the Chinese from developing science: "If scholars in China had wanted to do science, philosophy alone would not have been a serious impediment" (as cited in Stark, 2003, p. 151). There is no doubt that had Chinese scholars wanted to pursue science, they could have done so. The same is true of any culture. Stark (2003), however, asked the obvious question that seems to have completely escaped Lang: "Why didn't Chinese scholars want to do science?" (p. 151).

The relationship of faith and science is apparent in the case of the ancient Chinese, who were unable to break free from the constraints of their Eastern pantheism and belief in eternally repeating cycles, which together, stifled any serious desire to investigate and comprehend nature (Hannam, 2011; Jaki, 2000; Woods, 2005). The ancient Chinese possessed a manifest preference for the mystical over the physical and held a deep seated desire to seek enlightenment over explanations of natural phenomena (Stark, 2003). Their faith traditions shaped their perception of nature, which effectively barred the ancient Chinese from any serious investigation of the natural world and the possibility of science. The Chinese didn't want to do science because it never occurred to them that comprehending creation through scientific means was possible (Hess & Allen, 2008; Jaki, 1990; Jaki, 2000; Stark, 2003; Woods, 2005).

Ancient Greece

Ancient Greek intellectuals engaged in intellectual speculation as the primary means to explore questions related to society, the cosmos, and eternity (Lindberg, 1992). The word "philosophy" itself originated in ancient Greece and is derived from the Greek words *phileo* (*I love*) and *sophia* (*wisdom*) (Kuniński, 2008). The early Greek philosophers pursued universal explanations for a wide range of phenomenon, which had never been attempted on a large scale before them (Lindberg, 1992). But for all their intellectual contributions to philosophy and queries into the natural world, Greek philosophers never succeeded in freeing themselves from their pagan (i.e., nature controlled by the unpredictable whim of the pantheon of gods), pantheistic (i.e., the universe itself is divine and consequently subject to unpredictability), and animistic (i.e., all physical entities, such as, plants, animals, and inanimate objects possess souls, a spiritual essence – even desires) worldview that so deeply shaped their understanding of nature. As a consequence of their worldview, none of the early Greek philosophers engaged in authentic empirical science, involving theory, experimentation, and observation (Jaki, 2000; Woods, 2005).

A few examples from Greek antiquity will reveal how completely the pagan and pantheistic worldview shaped early Greek thought (Stark, 2003). The philosopher and poet, Hesiod, thought the Earth and sky were divine offspring (Lindberg, 1992). In 500 BC, Heraclitus explained that the heavenly bodies are bowls filled with fire, and an eclipse is caused by the open side of the bowl turning away from the Earth. Even historical events were interpreted through the pagan and pantheistic worldview. For example, the fifth century BC historian, Herodotus, noted that the departure of the Persian army from Greece coincided with an eclipse, which he interpreted as a supernatural omen (Lindberg, 1992).

The whole of the Greek philosophical corpus is vast and complex, but the scholarly consensus is that Greek philosophical enquiry culminated in the person of Aristotle (384 – 322 B.C.) (Hess & Allen, 2008). The ultimate concern of Aristotle and his followers was to perceive the *physis* or *nature* of things (Lindberg, 1992). Aristotle's intellectual influence endured for more than 2000 years (Grant, 2002) and he composed treatises on a stunning variety of subjects, including: logic, natural philosophy, metaphysics, biology, ethics, psychology, politics, poetics, rhetoric, and economics. His other works include *On the Heavens*, *On Generation and Corruption*, *Meteorology*, *On the Soul*, and *Metaphysics*. The language of natural philosophy was, for millennia, the language of Aristotle (Hannam, 2011).

Aristotle made considerable progress in the study of biology, but in a very real sense, the methodology that worked so well in biology was responsible for his failings in physics (Jaki, 1990; Woods, 2005). Aristotle's teacher, Plato, held an animistic view of nature and reasoned that everything behaves according to its nature (Jaki, 2000). Plato declared, "the deity, intending to make this world like the fairest and most perfect of intelligible beings, framed one visible animal comprehending within itself all other animals of a kindred nature" (as cited in Jaki, 1990, p. 105). Aristotle applied Plato's animistic notion to the study of biology with some success, but when he applied the same animistic notion to the study of physics he arrived at peculiar and erroneous conclusions. For instance, Aristotle reasoned that stones fall because of their love for the center of the Earth and the motions of the heavenly bodies are attributable to their intellective souls that desire circular motion (Grant, 2002; Woods, 2005). He also speculated that the flight of an arrow is attributable to something within the arrow itself (Hitchcock, 2012). Moreover, he believed that some animals (i.e., mice, eels, some fish, etc.) spontaneously generate, which he attributed to the animistic souls present in soil and water:

> Animals and plants are formed in the earth and in the water because in earth water is present, and in water pneuma is present, and in all pneuma soul-heat is present, so that in a way all things are full of Soul; and that is why they quickly take shape once it has been enclosed (Aristotle, 1949, section III. Xi., para. 2).

Aristotle's animistic worldview, wherein he attributed intellective souls or desires to inanimate objects in order to ascertain their purpose for existing, resulted in errors in physics that, unfortunately, were presumed correct for several centuries (Hannam, 2011).

Some contemporary philosophers have argued that if Aristotle is understood correctly, even his *Physics* can be interpreted as correct or mostly correct (Wiker, 2011). However, the development of science throughout history does not begin to support that thesis (Hannam, 2011; Jaki, 1990; Jaki, 2000; Stark, 2003). The long line of natural philosophers that extends more than a millennium from Aristotle through the whole of the Middle Ages and into the Renaissance were consistent in their interpretation and understanding of Aristotle's *Physics.* They meticulously examined Aristotle's physics and painstakingly, through time, exposed his errors – errors that are directly attributable to his animistic notions. In point of fact, science was unable to progress until Aristotle's errors in physics were discovered and abandoned (Hannam, 2011; Hess & Allen, 2008; Jaki, 1990; Jaki, 2000; Stark, 2003; Woods, 2005).

Aristotle's problematic conclusions in physics are directly attributable to three faith-based presuppositions he embraced (Woods, 2005). First, his belief in animism, wherein he attributed souls to inanimate objects, which led him to seek to discover the manner in which everything found in nature tended toward its value-loaded, most appropriate position (Jaki, 2000). Animism led Aristotle to conclude that all physical movement was caused by a desire to fulfill an objective or purpose. For Aristotle, since all things seek what is best, it logically follows that what is the best is also the most natural, and therefore, even the intensity of motion can be understood as a function of the 'magnitude' of the 'striving' observed in nature (Jaki, 2000). In the case of matter, an object's size or weight factored into the magnitude of which it 'strived' to attain its 'best' position. Hence, he erroneously reasoned that an object that weighs twice as much as another will fall twice as fast (p. 42).

The second faith-based assumption embraced by the vast majority of ancient Greek intellectuals is the pagan belief that a pantheon of gods control nature and all aspects of daily life (Woods, 2005). Jaeger contended that Aristotle argued in favor of a plurality of prime movers (i.e., gods) in his Metaphysics, although most medieval interpreters of Aristotle held that Aristotle favored a single prime mover (Weinberg, 1967, p. 20). In either case, the ancient Greeks did not conceive of a predictable, rational universe, controlled by physical laws, but rather, an unpredictable universe, absent of order beyond the whim of the gods (Jaki, 2000).

The third faith-based presupposition embraced by Aristotle was his steadfast belief in eternally repeating cycles, wherein all physical reality and events are determined to repeat in exactly the same way for all of eternity (Aristotle, 350 BC/2008). He expressed the depth of his belief in eternal cycles in the concluding section of Book IV of his *Physics*, wherein he emphatically asserts that even "…human affairs form a circle, and that there is a circle in all other things that have a natural movement and coming into being and passing away…for even time itself is thought to be a circle" (as cited in Aristotle, 350 BC/2008, Book IV Chapter 14 section, para. 7). His faith in eternally repeating cycles led him to denounce experimentation (Hannam, 2011); insofar as he reasoned that intentionally manipulating nature by way of experimentation would disrupt the natural course of things, as determined by the eternal cycles (Jaki, 1990; Woods, 2005). Also, he concluded that experimentation was simply unnecessary because, as

Socrates had taught; all truth could be reached through introspection alone – apart from experimentation (Hannam, 2011).

Aristotle's belief in eternally recurring cycles produced the unfortunate consequences that Greek science was devoid of experimentation and also led Aristotle to make a value judgment as to whether Greek civilization of his day was at the top or bottom of the cycle (Hannam, 2011; Grant, 2002). He famously concluded that Greek culture in 400 BC was at the top of the cycle, which resulted in a marked complacency in terms of the need for progress. Aristotle matter-of-factly discussed the correlation between eternal cycles and cultural history and explicitly taught that the inventions of his day had been invented innumerable times in previous historical cycles. He then, almost casually, added that the comfort provided by the technology and innovations available at that time represented the highest mark attainable (Jaki, 1990).

In keeping with Aristotle's calculation placing ancient Greece at the top of the cycle, there was really no pressing need to pursue science further (Jaki, 1990). For example, Aristotle's successor as director of the Lyceum, Theophrastus, proclaimed with great satisfaction that the material abundance of his own time was far superior to that of the time of the Trojan War. Theophrastus noted that life at the time of the Trojan War was "lacking in equipment...and the arts [crafts] had not been brought to perfection; the life of our own day on the other hand is equipped with everything conducive to ease, enjoyment, and amusements in general" (as cited in Jaki, 1990, p. 129). The belief that things were as good as they were going to get didn't portend well for the future of Greek science.

Three faith-based assumptions converged in ancient Greek thought, which effectively inhibited the development of authentic science: (1) Animism led to the conception that the universe itself is an organism in possession of a soul, a will, and desires, and its individual components (i.e., plants, animals, and inanimate objects); are also animated with souls (Woods, 2005); (2) The pagan belief that a pantheon of gods controls an unpredictable universe that is subject to the impulse of the gods at any given moment, as opposed to a rational, predictable universe; and (3) All of creation is subject to eternally repeating cycles, wherein all thoughts, actions, decisions, and occurrences repeat into infinity. Ancient Greek intellectuals judged that Greece was at the top of the cycle, which caused a marked complacency concerning discovery and innovation and also caused Aristotle to denounce experimentation on the grounds that it would disrupt the cycles of nature (Jaki, 1990).

Ancient Greek thought was inextricably tied to paganism, pantheism, and animism from Socrates to Aristotle and beyond (Jaki, 1990). A fertile environment for science is one in which a people possess an earnest desire – even a burning desire – for improvement and progress. Greek thought and Aristotelian thought in particular was held in such high regard that for centuries his *Physics* was simply accepted as necessarily true, almost dogmatically true, despite any evidence to the contrary (Hannam, 2011; Jaki, 2000). In the end, no ancient civilization of record conceived of a predictable, rational cosmos, which is are fundamental prerequisites of empirical science.

Summary of Ancient Civilizations and Science

Ancient Egypt, India, China, and Greece are representative of great pre-Christian cultures, in both their often remarkable achievements and startling shortcomings (Jaki, 2000; Lindberg, 1992; Stark, 2003; Woods, 2005). Each of these prominent ancient civilizations made discernible advancements toward science, but then neglected to follow up on those achievements, and, as a result, never achieved genuine science. Other notable ancient cultures prospered in different parts of the world, but they too perceived the natural world through a pantheistic, animistic, and pagan lens, which rendered similar results relating to science (Jaki, 1990).

The Aztec, Inca, and Maya civilizations embodied the pinnacle of cultural development in pre-Columbian America (Jaki, 1990). Although these ancient American cultures were very different from one another in several respects, they shared a similar fate in terms of advancements and failings towards developing authentic science. Like Egypt before them, the pre-Columbian American cultures made impressive strides in practical skills, alongside remarkable omissions (e.g., never having conceived of wheeled vehicles, pulleys, potter's wheels, or water wheels). In various degrees of explicitness the Aztec, Inca, and Maya civilizations, like all other pagan cultures, were the cultural embodiments of the pantheistic, animistic, organismic, and cyclic conception of the universe, which perceived the natural world to be subject to the whim of the gods, and thus, unpredictable. Science, however, presupposes a predictable universe subject to the laws of nature. Authentic science did eventually take root within civilization, but the culture that finally made that breakthrough was infused with a radically different worldview than that offered by pantheism (Jaki, 2000; Stark, 2003; Woods, 2005).

The Emergence of Christianity

As is the nature of civilizations, they rise to prominence and eventually fade into civilizations that replace them. And, like the meager and immature scientific approaches of ancient civilizations that were eventually replaced, so too were the pantheistic worldview and faith traditions that restrained the progress of science. Of particular interest to this discussion was the emergence of Christian theology, insofar as the Christian faith presupposes an ordered universe and because Christian theology is at the center of much of the current tension in American education. How the Christian worldview first enabled modern science to emerge and develop, though not without considerable struggles, is described in this section.

The progress of science within the Christian world is a multifaceted story, which includes the initial endurance of Christianity within the Roman Empire (Lucas, 2006), the marked influence of classical Greco-Roman learning on early Christian scholars (Lindberg, 1992), the eventual establishment of Christianity throughout the Roman Empire (Crocker, 2001; Hitchcock, 2012), the establishment of important centers of learning (Woods, 2005), the subsequent overrun of the Western Empire by various barbarian invaders (Lucas, 2006), the copying and preservation of classical texts in the midst of the chaos resulting from intermittent barbarian assaults (Woods, 2005), defense against Islamic invaders throughout Europe (Hitchcock, 2012; Reilly, 2010), the assimilation of knowledge gained from other cultures (Hannam, 2011; Jaki, 1990; Royal, 2006), and the eventual establishment of schools, and later, universities, which facilitated an explosion of new knowledge and enabled the methodical distribution of information (Lucas, 2006; Pernoud, 1977/2000; Woods, 2005).

As has been demonstrated herein, the rise of science within society cannot simply be presumed as a normal or natural phase of societal development (Stark, 2003). Yet, science did arise on the European continent during a specific historical era, during which time the Christian faith was diffused throughout European society and markedly shaped the prevailing worldview. The Christian outlook concerning nature, along with the theological underpinnings that shaped that outlook are both explored in this section.

The Logos

The idea of the *Logos*, as a universal principle that animates the world, appeared for the first time in the writings of the Greek philosopher Heraclitus (535-475 B.C.), who identified the *Logos* with fire or ignited air that penetrates the world (Lebreton, 1910). Later, the Stoic philosophers used the term "*Logos*" as a godlike animating principle and in keeping with their pagan faith, described different gods as personifications of the *Logos* (e.g., Zeus and Hermes). Aristotle applied the term "*Logos*" to describe reasoned discourse in rhetoric (Aristotle, 2010). Although Greek philosophers continued to develop the concept of a *Logos* as a controlling principle, the Greeks, in keeping with their pantheistic consciousness (i.e., equating God with all material substance and all natural phenomena, including the forces of the universe), eventually came to settle on the notion that the *Logos* is the universe itself ("Pantheism," 2013).

Judaism, as recorded in the Old Testament, attributed the creative act as the word of God (Genesis 1:3; Psalm 32:9; Sirach 42:15). The Hellenistic Jewish philosopher, Philo (20 B.C. – 50 A.D.), used the term "*Logos*" in a multitude of ways, as he attempted to synthesize Stoic philosophy with Jewish exegesis: (a) as an intermediary agent that God uses to govern the universe; (b) as the creative word of God; (c) as the revealer of God in the form of an angel; (d) as the totality of ideas; (e) as the intelligible world; and (f) the power that upholds the world and ensures its organization and development (Lebreton, 1910, para. 7).

St. Paul, a contemporary of Philo, was one of the earliest New Testament writers and he exhibited marked familiarity with Greek thought (Lebreton, 1910). The theology of the *Logos* is clear in Paul's writings, as he termed "Christ the power of God, and the wisdom of God" (1 Cor. 1:24), and "the image of God" (2 Cor. 4:4). To the Colossians he described Christ as "the image of the invisible God" (Col. 1:15), as "all things were created through Him and in Him" (Col. 1:16) and in Whom "all things hold together" (Col. 1:17). Paul was also the likely author of the New Testament's Epistle to the Hebrews, which portrays an elegant Greek style and purity of language (Fonck, 1910). The author of Hebrews proclaimed that Christ is the creator of the universe: "…we understand the world to be fashioned by the Word of God, so that the visible might be made by the invisible" (Heb. 11:3).

The theology of Christ as the *Logos* was advanced again by Paul, while he was in the midst of the pagan philosophers of Athens. Luke recorded in the Acts of the Apostles that Paul stood in the middle of the Areopagus, disputed with the Epicurean and Stoic philosophers and observed that among their altars and idols was an altar inscribed: "To The Unknown God" (Acts 17:23). Paul proclaimed that this unknown God does not "live in temples made with hands…since it is He who gives to all things life and breath and all else…For in Him we live, and move, and exist" (Acts 17:23-25, 28). Paul's theological depiction of Christ as the *Logos* lacks only the term itself (Lebreton, 1910, para. 9). The Greek term *Logos* would appear soon after in the writings of the apostle John.

John wrote his gospel in the latter half of the first century, within sixty years of the Jewish philosopher Philo's death (Hitchcock, 2012; Jurgens, 1970). The Gospel of John begins by announcing Christ as the *Logos*:

> In the beginning was the Word (*Logos*), and the Word was with God, and the Word was God. He was in the beginning with God. All things came to be through Him, and without Him nothing came to be…And the Word became Flesh and made his dwelling among us, and we saw His glory, the glory as of the Father's only Son (John 1-3, 14).

The First Epistle of John refers to Christ as "He who was from the beginning" and "He is the Word (*Logos*) of Life" (1:1). In the Apocalypse John again identifies Christ as the "Word of God" (19:3) and relays the words of Jesus: "I am the *Alpha* and the *Omega*, the First and the Last, the Beginning and the End" (22:13).

For the personal disciples of Jesus Christ, the *Logos* was not an unidentifiable underlying principle that animates, an animated universe, an intermediary agent between God and the universe, the totality of ideas, an impersonal power, the law that regulates the world, nor a Platonic ideal model of the world (Lebreton, 1910). Rather, the New

Testament writers consistently asserted that Jesus Christ is the creative Word (*Logos*) of God, Who from all eternity was in God and was God, and became Flesh and dwelled on Earth (John 1-14).

The Early Church Fathers (i.e., earliest Christian apologists, usually bishops of the post-apostolic era) of the patristic period (i.e., about A.D. 100-800) continued to proclaim Christ as the *Logos* (Lebreton, 1910). For example, the teaching of Christ as Divinity Itself is present in the writings of the earliest patristic father of record, St. Ignatius of Antioch (about 50-110 A.D.) – modern day Turkey. Ignatius was the third bishop of Antioch following Peter and Evodius, was a hearer of the apostle John, and thus, represents an important link between the apostolic and patristic periods (Jurgens, 1970). In 110 A.D., Ignatius, by order of the emperor Trajan, was being led to the Coliseum in Rome to be fed to the lions and during his journey he wrote seven letters to the various churches (Jurgens, 1970). In his Letter to the Ephesians he stated: "There is but one Physician, who is both flesh and spirit, born and not born, Who is God in man…" (as cited in Jurgens, 1970, p. 18).

Justin Martyr (110-165 A.D.) continued to proclaim Christ's divinity in his First (148-155 A.D.) and Second (148-161 A.D.) Apologies, which were addressed to the Roman Emperor Antoninus Pius and his adopted sons Marcus Aurelius and Lucius Verus (Jurgens, 1970). In his first Apology he wrote: "In the beginning He created us when we were not" (as cited in Jurgens, 1970, p. 51) and Justin continued his description of Christ as the divine *Logos* in his Second Apology (148-161 A.D.): "…in the beginning the Father created and put everything in order through Him – He is called Christ" (as cited in

Jurgens, 1970, p. 57). Tertullian (155-240) referred to Christ as the *Alpha* and the *Omega*. Origen engaged the Greek philosophers by recalling John's teaching "…the divine Word (Logos), who was in the beginning with God…as becoming flesh in order to reach everyone" (as cited in Royal, 2006) and Clement of Alexandria (d. 215) professed "the *Alpha* and the *Omega* of Whom alone the end becomes beginning" (as cited in Hassett, 1907, para. 1).

The early Christian understanding of Jesus Christ as the divine *Logos* is clear in the teachings of the early Church Fathers throughout the whole of the patristic period (Jaki, 2000). Early Christian apologists, such as, Irenaeus (140-202 A.D.), Hippolytus (d. 236 A.D.), Origen (185-253 A.D.), Eusebius (263-340 A.D.), and Athanasius (295-373 A.D.), attributed the inherent logicality and orderliness of the universe to the divine Person, Jesus Christ – the *Logos*. To the modern mind, the consistent teaching of the early Church concerning Christ as the *Logos* may seem obvious or over simplistic, but it represented a decisive moment in the history of science. The simplicity of their argument is striking: "If the Logos is fully divine, its creative work had to be a paragon of logic and order" (p. 83). The Christian conviction that the universe is fully rational is rooted in their trust, or rather, logically flows from their belief in the divinity of the *Logos* (Gregory, 2012; Royal, 2006).

From its inception, Christian theology made the radical claim that Jesus Christ is the rational, absolute, omnipotent, Creator and Lawgiver, Who by His nature, instilled absolute rationality in all of creation (Gregory, 2012; Horn & Wiedenhofer, 2008; Royal, 2006; Woods, 2005). For the first Christians, Christ revealed his divine nature by expressing His power over nature itself (i.e., walking on water, calming the sea, healing the deaf and blind, raising people from the dead, and raising from the dead, etc.). The perception of Christ as the very embodiment of the rationality and order of the universe (i.e., *Logos*) – a concept that was absent in previous cosmologies – ultimately provided a fertile environment for the development and sustenance of science (Hess & Allen, 2008; Jaki, 1990; Stark, 2003; Woods, 2005). The possibility of science was finally perceived and advanced only when security in the belief in a rational Creator of an ordered universe that the human intellect is competent to comprehend had sufficiently infused a culture (Hess & Allen, 2008; Jaki, 1990; Stark, 2003; Woods, 2005).

Early Christian Views on Greek Thought

The interface between early Christian thinkers with Greek learning must be considered in any serious exploration of the history of faith and science, as the early Christians were immersed in the Greek intellectual tradition (Lindberg, 2002). The Greek understanding of creation and the natural world was so unlike the Christian understanding that in formulating and defending the Christian position, the patristic fathers (i.e., 100-800 A.D.) were compelled to continually renounce several aspects of Greek pantheism (Jaki, 2000). Although, the vast majority of the patristic fathers accepted aspects of Greek learning that were deemed consistent with the Christian worldview and rejected that which was judged inconsistent (Grant, 2002; Lindberg, 2002). This selective use of Greek constructs eventually became the building blocks of modern science.

Unlike the pagan inclination to understand natural phenomena as a product of the impulse of the gods, the earliest Christians were remarkably consistent in their rejection of that position (Woods, 2005). Early Christian thinkers conceived of an entirely new view of creation, wherein the *Logos* was understood to be the first cause, Who operates in and through secondary causes and that view of creation ultimately led to a mature study of nature (Jaki, 1990; Lindberg, 2002; Stark, 2003; Woods, 2005). For the early patristic fathers, Christ the divine *Logos* brought into being and sustains a fully rational universe (Gregory, 2012; Royal, 2006). The patristic fathers reasoned that because the Logos is fully divine, its creative work had to be a paradigm of logic, rationality, and order (Jaki, 2000). Christian thinkers reasoned that the production of secondary causes, capable of accomplishing certain effects, would require greater power than the direct execution of those same effects (McHugh, 1911).

Because pagan speculations found in Greek philosophy sometimes contained insights that helped enhance theological concepts, the early Church Fathers were almost unanimous in their belief that Greek philosophy should be studied for that purpose (Grant, 2002). Thus, from early on Greek philosophy and natural philosophy were considered useful "handmaidens to theology" (p. 39). In the fifth century, St. Augustine summarized the Christian attitude toward pagan learning:

> If those who are called philosophers, especially Platonists, have said things which are indeed true and are well accommodated to our faith, they should not be feared; rather, what they have said should be taken from them as from unjust possessors and converted to our use (as cited in Lindberg, 2002, p. 52).

Despite portrayals of the early Church as a haven of anti-intellectualism comprised of opponents of natural science (Draper, 1874; Knight & Lomas, 2001; White, 1896) evidence in support of that opinion is absent (Grant, 2002; Pernoud, 1977/2000). During the first three centuries, even before Christianity was legalized by Constantine, the early Church Fathers were in continuous dialogue with members of the pagan Greco-Roman elite class (Lindberg, 1992). In the course of their dialogue, in which their primary purpose was to explain and defend their faith, they increasingly defined and refined the tenets of Christian doctrine. For example, in his work entitled *Against Plato, On the Cause of the Universe*, St. Hippolytus of Rome (235 AD) engaged Greek intellectuals and explained the Christian position on creation and the universe (Kirsch, 1910).

The most common example used in support of the early Church's supposed opposition to natural science is Tertullian (160 – 240 A.D.), which is somewhat ironic in light of the fact that Tertullian rejected Christianity in 206 in favor of the Montanist sect and then separated from the Montanists in 213 to form his own sect (Jurgens, 1970). It is true that on some occasions Tertullian voiced opposition to pagan learning, but his attacks were specifically directed toward the assignment of divinity to the various celestial objects (Lindberg, 2002). Tertullian aside, the record establishes that the patristic fathers addressed the pagan intellectuals on their own terms, conversed in their language, sometimes denounced specific aspects of Greek philosophy, but customarily utilized the Hellenistic methodology and parts of Greek content to explain the Christian position (Lindberg, 2002).

From the Christian theological perspective, the early Church Fathers' opposition to pagan thought was warranted, but most critical to this study is the fact that their steadfast opposition to several aspects of pagan thought was needed for the rise of science (Hannam, 2011; Jaki, 1990; Jaki, 2000; Woods, 2005). The early patristic writers unanimously condemned the pagan philosophers': (a) assignment of divine powers to various aspects of nature (Lindberg, 2002); (b) notion of an animated universe in possession of a life-giving soul; and (c) conception of eternally repeating cycles of birth-life-death and rebirth (Jaki, 1990). The earliest patristic writings asserted – for the first time in recorded history – that (1) creation came into existence at a particular point in time, as a result of (2) an intentional act by a personal God – the *Logos* – (i.e., as distinct from a pantheistic understanding that equates God with all physical reality and natural phenomena), and (3) neither the universe nor any of its physical elements can partake of divinity because the Creator, Who brought both time and space into existence, is outside of or beyond nature (Jurgens, 1970; Lindberg, 2002).

The Christian cosmological perspective represented an entirely new understanding of nature that was simply absent in all forms of Eastern and Western paganism (Jaki, 1990; Jaki, 2000; Woods, 2005). The apostolic assertion that Christ is the *Logos,* assumed an intrinsic order to the universe and the earliest Christians firmly believed people had been endowed by the Creator with the ability to discover that order (Hitchcock, 2012; Jaki, 2000; Woods, 2005). When finally perceived and accepted, Christian cosmology established an intellectual footing on which genuine empirical investigation of nature could proceed (Stark, 2003). Both the underlying order of the universe and the resolute belief in human rationality were consistently reaffirmed by Christian thinkers during the patristic period, which comprised almost the entire period known as the Dark Ages (i.e., from about 467 – 1000 A.D.). After 2000 years, an intelligible, predictable universe subject to the laws of nature that rational people are capable of comprehending, is so widely accepted that is has become the dominant worldview in the West. So much so, that it is difficult to imagine living within a pagan or pantheistic milieu, wherein the investigation of nature is regarded as counterintuitive (Hannam, 2011).

Because early Christian thinkers were immersed in the thoroughly pagan Roman culture, their theological and cosmological beliefs were initially unknown, unaccepted, and even ridiculed (Spitzer, 2010). As a result, they were continually compelled to refine and defend both their theological and cosmological positions against the prevailing pagan beliefs (Lindberg, 2002). Aristotle's cosmology, which was grounded in his physics, embodied the prevailing pagan perception of nature. Christian scholars rejected several aspects of Aristotle's physics on the grounds that they were incompatible with Christian theology. It is interestingly that much later it was discovered that those same Aristotelian errors in physics had actually inhibited the fruitful investigation of nature. The positive result of the eventual condemnation of several of Aristotle's propositions was to free natural philosophers from the bounds of Aristotelian physics, which accelerated the fruitful exploration of the natural world (Jaki, 2000; Woods, 2005). But first, Aristotle's errors in physics had to be exposed.

Incompatibility of Aristotelian Physics and Christian Theology

The central research question herein concerns fundamental philosophical and theological ideas that may have been accepted within Christianity, but rejected by other religions and cultures, which may account for the flourishing of science in Christian Europe alone. The early Church Fathers never envisioned a division between their theological beliefs and their perception of the natural world (Woods, 2005). Rather, they simply believed that God's creation is composed of both physical and spiritual realities, which are synthesized into a seamless reality. Likewise, theology was never thought of as mere personal beliefs. Early Christian intellectuals perceived that theology constituted a body of agreed-up facts and natural philosophy constituted a legitimate means of revealing the workings of God's creation (Hitchcock, 2012). Christian theological beliefs were simply part of the data set accepted by Christian natural philosophers that effectively shaped their worldview. That is, Christian theological beliefs were not mere external 'influences', but rather, provided a fertile foundation for scientific speculation (Principe, 2011, Religious Motivations for Scientific Investigation section, para. 1).

The ideological encounter between classical learning and Christian thought crystallized in Alexandria, where the Hellenistic practice of students gathering around a master continued (Jaki, 1990). The famous school at Alexandria was directed by the patristic father, Titus Flavius Clement (153-215) and his most renowned student, Origen (185-253). An early scholarly work by Origen (180-253) entitled *Commentaries on Genesis,* was preserved by the Church historian Eusebius (263–340) and demonstrates

Origin's impressive familiarity with the latest astronomical discoveries, including the procession of the equinoxes (Duhem, 1911).

However, it is apparent in the commentaries on Origin's work by other Church Fathers, notably St. Basil and St. Ambrose, that some were distrustful of Greek natural philosophy (Duhem, 1911). Basil and Ambrose expressed two reasons for their misgivings. The first was that astronomy was still so closely linked to astrology, which was a superstition that had been repeatedly condemned within Sacred Scripture. The second and very telling reason for their weariness of Greek natural philosophy, surrounded several propositions found in Aristotle's peripatetic physics (i.e., Aristotelian physics, which he discussed while walking about (peripatetic) the Lyceum in ancient Athens), which significantly conflicted with Christian theology (Ferngren, 2002; Hannam, 2011; Jaki, 1990; Jaki, 2000).

Peripatetic physics expressed Aristotelian ideas about creation and the operation of the universe that were both incompatible with Christian doctrine and would severely impede fruitful progress in physics for centuries to come (Grant, 2002; Hannam, 2011; Hess & Allen, 2008; Jaki, 2000; Lindberg, 2002; Stark, 2003; Woods, 2005). For example, Aristotle had asserted that God is not capable of giving the universe a rectilinear or straight motion because the universe would then leave a vacuum in its wake. Because Aristotle had asserted that a vacuum in nature to be a pure absurdity, he reasoned that God was incapable of producing one (Grant, 2002). Other noteworthy peripatetic propositions that ran counter to Christian beliefs were Aristotle's contention that God could not create several worlds and the notion of an eternal universe with no beginning and no end (Jaki, 1990).

From the Christian perspective, several peripatetic propositions were unacceptable because they served to put limits on God's omnipotent power (Grant, 2002). From a scientific point of view, the presumed accuracy of Aristotelian peripatetic propositions severely impeded the study of physics well into the 13th century. For example, until Aristotle's theory of motion was found to be in error and supplanted, the study of planetary motion was unable to significantly advance. Aristotle's physics were finally overcome in the 13th century, following the official condemnation of certain peripatetic propositions by the Bishop of Paris. That condemnation, although issued on theological grounds, had the effect of freeing natural philosophers to think beyond Aristotelian concepts in physics (Grant, 2002; Hannam, 2011, Lindberg, 1992; Woods, 2005).

From as early as the second-century, Christian scholars expressed their theological positions in the language of Greek philosophy and implemented elements of Greek philosophy they judge to be consistent with Christian thought (Lindberg, 2002). In terms of science, the debate between Christian and pagan intellectuals often centered on nature: the origins of the cosmos, the structure of the cosmos, celestial bodies and motions, the elements, the nature of sickness and health, and explanations of natural phenomena (lightning, thunder, eclipses, earthquakes, etc.). Those early discussions of various elements of the natural world represent the makings of what would centuries later develop into modern science. Thus, Western science originated as the Christian response to pagan beliefs concerning the natural world (Lindberg, 2002).

Because pagan apologists were often familiar with Christian claims regarding the Book of Genesis and creation, the patristic fathers were prompted to examine and express the meaning of the Genesis creation accounts (Maas, 1910). Thus, the meaning and interpretation of scripture was at the forefront of the ongoing dialog between early Christian apologists and their pagan counterparts, particularly as it related to creation and the natural world (Principe, 2011).

Christian Biblical Exegesis and Nature

Early Christian biblical exegesis (i.e., the critical explanation and interpretation of scripture) is of profound importance to this study because it provides a means to compare the ancient Christian scriptural interpretive tradition with that of the modern day Christian fundamentalist interpretive understanding, which has inevitably led to contemporary creation science claims (Jaki, 1990). The historical record indicates that although various interpretations of the Genesis creation accounts were advanced, including a literal and an allegorical reading, very early on the patristic fathers settled on an exegetical tradition that was generally accepted by the great majority Christian theologians for well over a millennia (Augustine, 415/1982; Principe, 2011).

Every civilization had speculated as to the origin of the cosmos, but the Christian understanding of creation seems to have largely defined the future of science (Jaki, 1990; Woods, 2005). Several early pagan writers were familiar with the Christian claims regarding creation, including the *Hexaemeron* (i.e., six-days' work of creation), which signifies the so-called second creation account described in the first Book of Genesis (Jurgens, 1970). The marked difference between the early Christian versus pagan beliefs concerning the cosmos is exemplified by the fact that pagan intellectuals ridiculed the early Christians for their insistence that the universe is not eternal, but came into being at a specific point in time *ex nihilo* (i.e., *out of nothing*) (Spitzer,2010).

In 220 AD, the early Church Father, Origen, commented on the complexity of Scripture: "...it is of ecclesiastical teaching that the Scriptures were written through the Spirit of God, and that they have not only that meaning which is quite apparent, but also another which escapes most," and added, "for the words which are written are the forms of certain mysteries, and the images of divine things. In this matter the opinion of the whole Church is one" (as cited in Jurgens, 1970, p. 192). Origen went on to describe the various layers of truth conveyed in Scripture, (i.e., literal, mystical, spiritual):

> Each man, then, ought to have the meaning of Sacred Scriptures inscribed in a three-fold manner upon his soul. Thus, the simple man may be edified as if by the flesh of the Scriptures – for so we name the obvious sense. He that has ascended somewhat may be edified as if by the soul of the Scriptures. The perfect man, again,…may be edified by the spiritual Law, which casts a shadow of the good things to come. For just as man consists of body, soul, and spirit, so also does Scripture… (as cited in Jurgens, 1970, p. 198).

In 226, Origen wrote a commentary on the Gospel of John, wherein he clearly asserted that the biblical authors sometimes wished to express a pneumatic (spiritual) truth, at other times a somatic (literal) truth, and sometimes both simultaneously (Jurgens, 1970). Origen explained that the biblical authors, "…often preserved the pneumatic truth in what some might call a somatic falsehood" (as cited in Jurgens, 1970, p. 202). Origen was explaining to those who would challenge the validity of Sacred Scripture, based on apparent somatic (literal) contradictions, that in those cases the truth of God's revelation is present in the pneumatic (spiritual) sense.

Following Origen's example, Christian scholars at the famous school at Alexandria continued developing biblical exegesis, alongside the study of natural philosophy (Jaki, 1990). Any lingering uneasiness toward the study of nature among Christians was forever put to rest by the monumental figure of St. Augustine of Hippo (354–430), who settled the issue concerning the synthesis of Christian theology and the study of natural philosophy (Jaki, 1990; Woods, 2005). His explanations sufficed until the onset of the Protestant Reformation eleven centuries later. Augustine's scriptural interpretative methodology resulted in exegetical rules that when applied, seamlessly enabled Sacred Scripture to be synthesized with truths found in nature (Principe, 2011).

Augustine eventually settled on an understanding of Sacred Scripture that was very similar to that of Origen's two centuries earlier, in that he too discerned multiple layers of truth within Scripture (Jaki, 1990; Principe, 2011). That is, he taught that a scriptural passage may express a literal truth or a mystical (allegorical) truth or both simultaneously – even layers of spiritual truth. In Augustine's view, if a passage was not intended to express a literal truth, it does not detract from God's revealed revelation to utilize the passage's spiritual sense. Augustine deferred to the authority of the Apostle Paul, who had taught that New Testament revelations can be glimpsed in the Old

Testament, sometimes in literal and other times in figurative ways (O'Donnell, n.d.). Augustine's exegetical teaching and methodology can be traced as a discernible thread that permeates Christianity through the centuries – even to the present (Jaki, 1990).

In 415, Augustine demonstrated his keen familiarity with Greek thought as he bluntly affirmed the historical Christian position on the proper interpretation of Scripture and the Book of Genesis in particular, in his book entitled *De Genesi ad litteram* (*The Literal Meaning of Genesis*):

> Usually, even a non-Christian knows something about the earth, the heavens, and the other elements of this world, about the motion and orbit of the stars and even their size and relative positions, about the predictable eclipses of the sun and moon, the cycles of the years and the seasons, about the kinds of animals, shrubs, stones, and so forth, and this knowledge he holds to as being certain from reason and experience. Now, it is a disgraceful and dangerous thing for an infidel to hear a Christian, presumably giving the meaning of Holy Scripture, talking non-sense on these topics; and we should take all means to prevent such an embarrassing situation, in which people show up vast ignorance in a Christian and laugh it to scorn. The shame is not so much that an ignorant individual is derided, but that people outside the household of the faith think our sacred writers held such opinions, and, to the great loss of those for whose salvation we toil, the writers of our Scripture are criticized and rejected as unlearned men. If they find a Christian mistaken in a field which they themselves know well and hear him maintaining his foolish opinions about our books, how are they going to believe those books in

> matters concerning the resurrection of the dead, the hope of eternal life, and the kingdom of heaven, when they think their pages are full of falsehoods on facts which they themselves have learnt from experience and the light of reason (as cited in Augustine, 415/1982, p. 42).

Augustine's fifth century approach to hermeneutics (i.e., study of the principles of interpretation of scripture) concisely outlined the historical Christian position in reference to how Old Testament Scripture should be understood (Jaki, 2000; Portalie, 1907). He meticulously studied the creation accounts depicted in the Book of Genesis and produced his *De Genesi ad litteram* (*The Literal Meaning of Genesis*), wherein he specifically warned against an insistence on a literal interpretation of Scripture, which is inconsistent with demonstrable evidence to the contrary: "We must be on our guard against giving interpretations which are hazardous or opposed to science, and so exposing the word of God to the ridicule of unbelievers" (as cited in Portalie, 1907, para. 15). He was adamant that such a position would undermine the credibility of the Christian message by instilling in the minds of unbelievers that the Bible was wrong on points "…which can be verified experimentally, or to be established by unquestionable proofs" (as cited in Jaki, 1990, p. 183).

Augustine endeavored three different times to describe creation in six, 24-hour days, but each attempt ended in an allegorical interpretation (Maas, 1910). The prominent Protestant theologian, Alister McGrath, puts the number at four different attempts by Augustine (McGrath, 2012). He started with a literal interpretation in the year 389, again in 393, and again in 401, but was perplexed by the specific questions:

“Did God consume the whole day in creating the various works? How could there be days before there were heavenly luminaries? How could there be light before the existence of the sun and the stars” (as cited in Maas, 1910, para. 34). His great mind was compelled to settle on an allegorical interpretation in which the six-days signify an order of dignity (i.e., angels, the firmament, the earth, etc.).

For Augustine, the creation accounts in Genesis affirmed that God is the author of all terrestrial life, but did not resolve the question as to whether God had created all life in its current state and diversity in six literal days (Hess & Allen, 2008). He maintained that although the universe had come into being in a single creative act, he proposed that God had instilled *rationes seminales* (rational seeds) in nature that would, over time, bring forth life in its current diversity. Augustine’s concept of *rationes seminales* did not, of course, suggest an evolutionary model wherein one species evolves into another, but it did introduce a gradualistic theory of development that was seriously discussed well into the Middle Ages (p. 68).

Augustine’s judgment was echoed through the centuries by a host of Christian theologians, including Isidore the Bishop of Seville (560–636), the abbot of the monastery of St. Martin of Tours and member of Charlemagne’s court, Alcuin (735–804), the theologian and scholar, John Scotus Eriugena (800–877), and the 11th century philosopher and theologian, Abelard (1079–1142) (Maas, 1910). Church Fathers who preceded Augustine, such as St. Basil (329–379), St. Jerome (340–420), St. John Chrysostom (347–407), and later St. Gregory the Great (540–604), had also perceived and sought to illuminate the multiple senses found in Scripture (Maas, 1909). The rejection of a strictly literal interpretation of scripture in favor of multiple senses was continued by the Scholastics in such figures as St. Bernard (1090–1153), St. Thomas Aquinas (1225–1274), the Spanish Dominican theologian Domingo Banez (1528–1604), the theologian Francis Sylvius (1528–1604), Jesuit Fr. Cornelius a Lapide (1567–1637), John of St. Thomas (1589–1644), and a multitude of other Christian theologians (Maas, 1909).

Theologians describe a literal interpretation of scripture as non-concordist because those who accept only a strictly literal interpretation place no importance on the harmony between inspired scripture and the laws of nature (Maas, 1910). Literal, non-concordist, interpreters of Sacred Scripture can be found in history, but represent a small minority. For example, the Scholastic philosopher and Doctor of the Church, St. Bonaventure (1221–1274), held a non-concordist position, but was notably modest and tolerant of the opinions of others. Although he himself held to a literal interpretation of the first two chapters of Genesis, he willingly acknowledged the potential for other interpretations and specifically referred with admiration to the figurative understanding that had been advocated by theologians since before the time of St. Augustine. Bonaventure also emphatically denied the authority of his personal opinions, referring to himself as a "poor compiler" (as cited in Robinson, 1907, para. 13).

Conversely, Bonaventure’s contemporary, Thomas Aquinas, held that the Book of Genesis presented no difficulties for the natural sciences and that the natural sciences presented no difficulty for the Christian faith because the Bible is simply not a textbook in the sciences (Carroll, 2000). For Aquinas, the reality of creation is essential for the faith, not the particular mode or manner through which God formed the cosmos and world. In fact, he went further and asserted that the manner and order of creation are incidental to the Christian faith (Carroll, 2000).

The ancient history of Jewish biblical exegesis exhibits the same recognition of the literal and mystical layers present in Scripture (Maas, 1909). Director of the Elie Wiesel Center for Judaic Studies at Boston University, Steven T. Katz, commented on the Genesis creation account: “In Jewish religious thought Genesis is not regarded as meant for a literal reading, and Jewish tradition has not usually read it so” (as cited in Tigay, n.d., para. 15).

Church history simply does not support the notion that the genuine meaning of the *Hexaemeron* is self-evident (Maas, 1910). Through the course of centuries, many interpreters have offered differing interpretations and opinions concerning the creation accounts depicted in the Book of Genesis. One such interpretation is a literal, non-concordist, explanation of the *Hexaemeron*, which insists on a literal, six-day creation with days represented as literal 24-hour periods. However, notwithstanding claims of some contemporary Christians, an allegorical understanding of the *Hexaemeron* held precedence among the great majority of theologians and Christian commentators from the early patristic period, until the onset of the Protestant Reformation in the 16th century (Wiker, 2011; Woods, 2005). Interpreting the creation accounts contained in the Book of Genesis in a literal versus allegorical sense has proven to have marked consequences for how claims of modern science are judged and integrated into contemporary science education curriculum (Skehan & Nelson, 2000).

From the early patristic period (approximately 100 – 800 A.D.), Christian theologians perceived layers of truth within Sacred Scripture. But they were generally careful to not simply quote scripture in their ongoing disputes with their pagan counterparts concerning the natural world. Time and again, Christian thinkers chose to formulate arguments concerning the natural order that were distinctly rational, grounded in nature, and outside of the bounds of theology (Augustine, 415/1982; Hess & Allen, 2008; Jaki, 2000).

Natural, Nonmystical Approach to Understanding Nature

The central research question concerns the possible existence of fundamental philosophical and theological beliefs present in Christianity that are distinct from other religions and cultures that may have enabled the genuine investigation of the natural world. Christianity helped free natural philosophy from the confines of a non-rational, unpredictable worldview and universe, which permeated all previously recorded pagan and pantheistic cultures (Jaki, 2000; Woods, 2005). Correspondingly, Augustine helped free natural philosophers from the confines of a literal interpretation of Scripture, as he continually sought to emphasize the reasonableness of Christianity (Augustine, 415/1982; Jaki, 1990; Jaki, 2000). Augustine perceived nature through a distinctly Christian lens and did not resort to quoting Scripture or the use of theological arguments when debating things of the natural order. He did the same when refuting the claims of pagan charlatans. For example, one of Augustine's arguments in opposition to astrology (i.e., attempting to foretell the life fortunes of people, based on the position of the stars and planets) was framed in distinctly natural, as opposed to theological terms (Hess & Allen, 2008). In the fifth chapter of his work *The City of God*, Augustine ingeniously pointed out that astrologers had never been able to explain the differences in the life fortunes of twins:

> Twins are often less like each other than complete strangers; yet, twins are born with practically no interval of time between their births and are conceived in precisely the same moment of a single sexual semination (Hess & Allen, 2008, p. 11).

Augustine was certainly not alone among Christian intellectuals in his high regard for reason and insight concerning the things of nature, nor did the desire to investigate the things of nature cease with him (Hannam, 2011; Jurgens, 1970; Lindberg, 2002; Woods, 2005). Soon, however, Augustine witnessed the beginning of the collapse of the Western Roman Empire, during which scholarship of all kinds suffered a severe setback (Crocker, 2001; Hitchcock, 2012).

Collapse of Society and Preservation of Learning (476 A.D. to 1000 A.D.)

As this research, in large measure, concerns the historical events between the fall of the Roman Empire and the Renaissance that may have been foundational to the rise of science, it is clear that the collapse of Western civilization itself and the consequences are profoundly important to this study. Barbarian invasions so devastated the Roman Empire that the Greco-Roman intellectual tradition was threatened with extinction, including all extant speculations concerning natural philosophy (Woods, 2005). Various barbarian tribes invaded the Roman Empire in 406, 410, 421, 429, 451, 455, and the last Roman Emperor in the West, Romulus Augustulus, was deposed in 476 (Crocker, 2001;

Hannam, 2011; Hitchcock, 2012). Within two centuries, civilization on the European continent had collapsed and toward the end of the fifth-century obtaining an education was barely possible because of the seemingly unrelenting invasions. Mere self-preservation was the overriding concern for the overwhelming majority of people (Lucas, 2006).

Inevitably, the collapse of the Western Roman Empire hastened the decline of most educational opportunities within society (Lindberg, 1992). The Germanic tribes were, at best, disinterested in education and, at worst, disdainful of it. However, different regions of the vast former empire experienced different problems and levels of turmoil associated with the invasions. Whereas, Roman Britain and northern Gaul (present day France) were quickly cut off from the classical tradition, areas bordering the Mediterranean suffered a more gradual deterioration. Still, in spite of the turmoil, Lindberg (2007) observed that schools and intellectual pursuits continued, and in some cases even prospered, in Rome, northern Italy, southern Gaul, Spain, and North Africa.

Even in the face of anarchy, Church sponsored schools did manage to exist and function in Avignon, Marseilles and Lerins, which had been essentially isolated from barbarian invasion (Lucas, 2006). Virtually without exception the only European schools in existence during that time were Church sponsored (Woods, 2005). Monastic communities at Milan, Vercelli, Vivariium, Monte Cassino, and many others across the continent, took up the education of the youth (Lucas, 2006). St. John Chrysostom (347-407) noted that in his day it was customary for people to send their sons to the monks in Antioch to be educated. St. Patrick (387-461) is credited with the establishment and encouragement of Irish scholarship and the Irish monasteries developed into important centers of scholarship for monks and laymen alike. St. Benedict (480-543) instructed the sons of many Roman nobles. St. Augustine of Canterbury's (d. 604) monks in England established schools in every monastery he founded, as did St. Boniface's (d. 754) monks in Germany. The monasteries were specifically targeted for periodic looting and burning because of their ecclesiastic possessions, such as altar vessels of gold and silver, which were oftentimes adorned with precious stones. But the monks' persistent determination to carry on was crucial for the continuation of Western scholarship because of their labors in preserving Greco-Roman learning (Hitchcock, 2012). For example, the monastery of Monte Cassino was plundered by the Lombards in 589, but the monks managed to collect the manuscripts, escape to safety, and painstakingly rebuild when trouble had passed (Woods, 2005).

In the midst of the turmoil visited upon the former Roman Empire by the various barbarian tribes, a new religion took root in the East and made significant incursions into Western Europe (Royal, 2006). Islam's initial encounter with science largely reflected the Christian worldview they arose within, which by then had existed for 600 hundred years. Soon, however, Islam experienced an internal theological debate that profoundly changed their understanding of nature and the cosmos and had tragic consequences for science in the Islamic world (Carroll, 2007).

Islam's Encounter with Science

In many respects, Islam exemplifies how fundamental theological ideas serve to inform and shape the worldview of even entire civilizations. The Islamic world, like the other religions and cultures examined herein – with the sole exception of Christianity – eventually developed a worldview that prohibited a genuine study of nature (Reilly, 2010). Islam experienced a fundamental shift in their perception of God's relationship to the universe, which eventually led to the extirpation of science in the Islamic world. Moreover, as Islam increasingly seized what were formerly Christian territories, the encounters between Islamic and Christian scholars often advanced science (Jaki, 1990).

In 622, Mohammed, who is regarded as an Arabian prophet, founded Islam and by the time of his death in 632, almost the entire Arabian Peninsula had been united under Islam (Ferngren, 2002). Beginning in about 610, Mohammed began to proclaim the message of monotheism and call for the unity of Islam under Allah, which stopped much of the near-constant raiding between tribes, but at the same time, Islam divinely sanctioned what amounted to a mega-tribal raiding of the entire non-Muslim world. According to Mohammed's revelation, it was now right and just that non-Muslims should be subdued and ruled by the true followers of Allah (Reilly, 2010). Succeeding conquests of non-Muslim areas were staggeringly successful, and by 650 Muslims ruled Arabia, Iraq, Syria, Lebanon, Palestine, and Egypt (Reilly, 2010; Royal, 2006). A century later, Islamic control had spread from the fringes of China and India in the East to North Africa and as far West as Spain.

From the beginning, Islam was extremely suspicious of anything outside itself, but through conquest was increasingly exposed to foreign cultures, which predictably possessed very different traditions and thought. Islam's initial answer to foreign thought, particularly other religious beliefs, was to enact a sort of intellectual quarantine and claim superiority over all previous revelation by any religion. However, in many ways, the intellectual quarantine inhibited scholarly progress. For example, the historian, Ibn Khaldun, recalled the Muslims conquest of Persia, in which a huge quantity of captured books and scientific papers were captured. The general, Sa'd bin Abi Waqqas, requested permission of the caliph Omar to distribute the books and scientific papers as booty for his army, but Omar responded, "Throw them in the water. If what they contain is right guidance, God has given us better guidance. If it is error, God has protected us against it" (as cited in Reilly, 2010, p. 13).

Following the Islamic conquest of the Christian Byzantine territories, wherein Greek philosophy had long been synthesized with Christian apologetics and theology, the intellectual isolation imposed by Islam proved to be untenable (Reilly, 2010). Since late antiquity, centuries before the rise of Islam, the Near East had been exposed to Hellenistic thought when early Christians established renowned centers of learning in Syria and Persia, in which they translated Greek texts into several Near Eastern languages, including Syriac and Arabic (Carroll, 2007). Thus, prior to the rise of Islam, early Christian scholars from the East had translated a large portion of the "intellectual sciences" included logic, philosophy, natural philosophy, medicine, engineering, and mathematics. The conquering Arabs referred to these disciplines, which at the time they were wholly unfamiliar, as "intruding sciences" (as cited in Reilly, 2010, p. 13). Eventually, however, due to their immersion in what was formerly a deeply Christian culture, Muslims acquired an interest in the Greek sciences, but an interest that was centered on solving practical problems, such as in medicine, mathematics, natural science, alchemy, and astrology (Reilly, 2010).

Another result of the rapid conquest of Christian areas was that the early Muslims were lured into the long-standing philosophical and apologetic dialogue that Christians had continued since pagan times five centuries earlier (Reilly, 2010). Some Muslim converts from Christianity were already well versed in Greek learning and prepared to enter the apologetics dialogue on behalf of their newfound faith. Soon afterward, Islamic intellectuals became enamored with Greek philosophy and began to use newly created Arabic words to describe Greek philosophical concepts. The influence of Hellenistic philosophy on Islamic thought became apparent when a new kind of discourse took shape within Islam, which before had been almost exclusively doctrinal and jurisprudential. The Muslim mind which hitherto had largely been absent of the spirit of free inquiry and speculative thought, experienced its intellectual zenith during the eighth and ninth centuries (Reilly, 2010).

Islamic thinkers encountering Hellenistic thought began to face challenging questions, which Christianity had encountered and addressed several centuries before (Jaki, 1990; Reilly, 2010). Issues, such as, the status of reason itself, reason's ability to understand reality, whether God can be known rationally, whether reason precedes faith, and how reason comports with the teachings of the Qur'an were vigorously debated within Islamic intellectual circles. In the ninth and 10^{th} centuries, during the Abbasid caliphate, a philosophical battle ensued over the answers to these questions and nothing short of the notion of the human person's free will and whether or not people possess the ability to comprehend through reason was at stake. Unfortunately, although some Islamic philosophers argued forcefully on the side of reason, the triumphant side gradually extirpated philosophy and de-Hellenized the Muslim world (Reilly, 2010).

Regrettably, in relation to science, like the Greek and Roman pagans before them, even those within Islam who forcefully argued on the side of reason were scientifically hamstrung by their unswerving acceptance of the Neoplatonized version of Aristotle's peripatetic physics (Ferngren, 2002; Jaki, 1990). The result was that many of the leading influential Islamic intellectuals accepted propositions in peripatetic physics – propositions that had been rejected by Christian apologists several centuries before. Even Averroes, the most renowned of Eastern Aristotelian commentators, was a leader in disseminating the Neoplatonic Aristotelian cosmology (Carroll, 2007; Ferngren, 2002; Jaki, 1990; Reilly, 2010).

Thus, many Islamic thinkers returned to the idea that creation is an internal process of emanation, wherein celestial objects and other inanimate objects possess intellective souls, which cause planetary motion (Ferngren, 2002; Grant, 2002; Jaki, 1990). Notwithstanding the Qur'an's specific condemnation of astrology and communication of an absolute beginning of creation, the planets were thought to influence earthly events and leading Islamic thinkers became increasingly enamored with astrology as a means to predict the future (Ferngren, 2002). Islamic scholars also revived the Aristotelian notion of eternally repeating cycles (Jaki, 1990). The consequence for science was that peripatetic physics served to stifle any potential for sustained scientific inquiry by even those Islamic thinkers who were inclined to accept the primacy of human reason (Carroll, 2007; Jaki, 1990; Reilly, 2010).

Early Islamic Achievements in Science

Prior to the culmination of the philosophical and theological debate within Islam that signaled the expiration of scientific discovery in the Muslim world (Carroll, 2007; Ferngren, 2002; Reilly, 2010), Islamic scholars made important scientific advances (Jaki, 1990). The Houses of Wisdom was established in the beginning of the ninth century during the reign of the caliphate, al-Mamum (813–833), along with an academy and observatory in Baghdad. The caliph, al-Hakim, established an institute of higher learning in the newly constructed city of Cairo in 966. The caliph, al-Hakim II (961–976) founded a library in Cordova that possessed over 300,000 volumes, which almost immediately began to attract Christian scholars from the West (p. 193). The Arabs had acquired the Chinese art of paper making by the end of the eighth century, which greatly enhanced their efforts in translating the remainder of the Greek scientific and philosophical corpus into Arabic (Lindberg, 1992). They demonstrated scholarly meticulousness and exactness in their translations, along with the desire to not miss any available document. Essentially, they searched far and wide to find extant documents (Ferngren, 2002; Jaki, 1990).

Principally due to Arab translations, Galen's work on medical practice and teaching dominated the medieval East and largely influenced the West well into the Renaissance (Jaki, 1990). Islamic scholars showed a keen interest in the ancient medical works of Galen. The primary translator of Galen's medical works was the Arabic physician, Hunayn, who himself authored several medical treatises. He was most probable author of *The Book of the Ten Treatises on the Eye,* which initiated the systemization of ophthalmology. He founded a school of medicine, where he was the teacher of the most famous figure of Arab medicine, al-Razi (865–925), who authored *A Treatise on the Small-pox and Measles*, which has been reprinted more than 40 times in the last four centuries. Al-Razi also accumulated the whole of Greek, Syriac, and early Arab medical knowledge in addition to ample material from Persian and Indian medical sources, which he amassed in a medical encyclopedia entitled the *Comprehensive Book* (Jaki, 1990, p. 194). Muslim physicians maintained keen interest in the eye well into the 14th century, long after the zenith of Islamic science had passed (Jaki, 1990). Al-Shadhili wrote the last notable Arab work on ophthalmology in approximately 1375. Muslim physicians were familiar with the anatomy of the eye, its diseases and treatments, and could perform some operations, particularly on cataracts. For example, the 13th century caliph, Ibn-abi-al-Mahasin, was also a surgeon and was renowned for his ability to remove cataracts (p. 195).

Islamic ophthalmology also provides an example into the problem of why Islamic science failed to endure (Jaki, 1990). One of the most incisive of Arab ophthalmologists was Ibn-Rushd (1126–1198), but he is much better known as Averroes, the most renowned Aristotelian commentator in the East. Averroes’s unfailing servitude to Aristotelian physics was not a detrimental factor when practicing the practical science of ophthalmology. Aristotle's worldview did not affect the practice of medieval medicine, as, for instance, his notion of gravity or momentum affected the study of physics.

Consequently, "Muslim science made notable contributions to those parts of science which had, in the historical context at least, little or nothing to do with the laws of the physical world at large" and this was also true for Arab contributions to mathematics (p. 195).

Arab mathematicians were familiar with algorithms as early as the ninth-century and showed originality in the study of trigonometry, which they had inherited from the Greeks (Jaki, 1990). The Hindus in India had invented decimal notation, but Arab mathematicians were instrumental in giving Hindu numerals in decimal notation a more explicit form, which successfully challenged the use of cumbersome Roman numerals. Arab scholars also broke new ground in optics, the question of balance, and made strides in understanding the laws of the propagation of light rays. The first Arab treatise on optics was written by Ibn-al-Haitham (965–1038) and is entitled *Kitab al-manazir* (*Book About Optics*) (p. 197).

Although early in their history, Islamic scholars made great strides in several areas of science (Royal, 2006), successors did not continue and sustain those efforts (Jaki, 1990). Although important gains were made in various disciplines, some of those disciplines were eventually perceived negatively within Islam because of the tendency on the part of Islamic practitioners to inject superstition. For example, time and again the Muslim world denounced chemistry as a worthless enterprise because of the tendency of its practitioners to treat it as alchemy (i.e., medieval attempts to produce gold, silver, and the elixir of life by combining various elements and chemicals). An odd mix of genuine science and superstition tempered Islamic achievements in science, which ultimately contributed to its demise. For example, al-Kindi, who was an outspoken critic of alchemy, was also a staunch supporter of astrology. The Arab scholar, al-Biruni, denounced the idea of determining the fate of nations, rulers, religions, and individuals based on the positions of the planets along the twelve signs of the zodiac. But then claimed it was perfectly reasonable to compute cycles and to list the horoscopic significance of each day using the ancient calendars (p. 198).

Secondary Laws of Nature Denied

Enquiry inspired by the central research question herein, concerning the existence of theological and philosophical ideas that may have influenced the development of science, uncovered an interesting circumstance unique to Islamic religious history. A fiercely contested philosophical and theological debate among Islamic scholars concerning the importance of reason ultimately determined the fate of science within the Islamic world (Ferngren, 2002; Jaki, 1990; Reilly, 2010). The Hellenized Islamic philosophers Avicenna and Averroes came down on the side of reason, but with the caveat and intellectual impediments inherent in Aristotelian peripatetic physics. Their adversaries, al-Ashari and Al-Ghazali (1058–1111) adamantly denounced the notion of scientific laws, as blasphemous and irrational. They reasoned that the existence of laws of nature would deprive Allah of His sovereign freedom to act, and thus, would be an affront to Allah's supreme will (Stark, 2003).

Al-Ghazali made a frontal assault against reason that was tantamount to the abandonment of a causal connection between any and all phenomena (Jaki, 1990). He declared that any apparent connection between fire and burning, light and sunrise, medicine and healing, are simply illusions that Allah creates and annihilates every instant, along with the rest of creation (Reilly, 2010). That is, there is no necessary connection between fire igniting cotton and producing smoke because Allah simply produces the illusion of fire (Ferngren, 2002). Al-Ghazali declared that the apparent causal connections in nature, including fire and heat, "or any other set of events observed to be connected together in medicine, or astronomy, or arts, or crafts... are connected as the result of the Decree of God (holy be his name), which preceded their existence" (as cited in Jaki, 1990, p. 205). Al-Ghazali determined that human reason had to stop at the observation of simultaneity, sequence, and cause-and-effect, thereby rejecting any obvious inference to causality. He proclaimed that all seemingly related phenomena are illusions that are exclusively attributable to the sovereign will of Allah (Jaki, 1990; Reilly, 2010; Stark, 2003). Genuine science is only possible under the realization of cause-and-effect (Jaki, 1990).

Other traditional orthodox Muslim groups failed to advance genuine science and showed little interest in separating the observational from the mystical and the logical from the political (Jaki, 1990). The *Ikhwa al Safa* (Brethren of Purity) attempted science by producing an encyclopedic summary of knowledge that consisted of 52 treatises that were grouped into four books. The first concerned mathematical and educational topics, the second with the natural sciences, the third with the theory of knowledge, and the fourth book dealt with theology. Regrettably, the end result was a demonstrated fixation with Pythagorean number mysticism, the Hellenistic conception of the world as an organism, the belief that the world possesses a soul, and the hierarchical ordering of every aspect of the universe. Principally, the Brethren of Purity held to a pantheistic conception of the universe and vehemently condemned “charlatans” who tried to predict the future without careful "scientific" study of the position of the planets (p. 206). They held that reliable astrology could confidently interpret the past, present, and future on the basis of the position of the planets. Like other orthodox Muslims, the Brethren of Purity replaced the fixed laws of nature with a pantheistic worldview. It is ironic that the emphasis within Muslim theology on the supremacy of transcendental unity, inevitably led to pantheism (MacDonald, as cited in Reilly, 2010, p. 111).

Consequences of Denying Secondary Laws of Nature

Within 100 years of Al-Ghazali's book *The Incoherence of the Philosophers*, Averroes tried in vain to counter the damage that had been done (Reilly, 2010). It was too late. Al-Ghazali's staunch Muslim orthodoxy captured the minds of the ruling class and quickly filtered through the Islamic people. One hundred and eight of Averroes's books were burned in the town square of Córdoba and his teaching of philosophy was banned. With the exception of his *Metaphysics,* which Christians in Europe preserved and translated into Latin and Hebrew, the vast majority of Averroes’s commentaries on Aristotle were incinerated in the East (p. 121).

The effects of Al-Ghazali's thought within the Muslim world were evident almost immediately (Reilly, 2010). In the 13th century, the head of one of the most prestigious institutions for the study of Hadith within the Islamic world, Ibn-as-Salab (d. 1251), proclaimed:

> …all those who give evidence of pursuing the teachings of philosophy must be confronted with the following alternatives: either execution by the sword, or conversion to Islam, so that the land may be protected and the traces of those people and their sciences may be eradicated (as cited in Reilly, 2010, p. 122).

As a consequence of Al-Ghazali's teaching, more than two centuries after the construction of the famed Blue Mosque, Turkish architects still could not calculate the lateral pressures of arches (Jaki, 2000). They also possessed no understanding of the catenary curve, which was so useful in constructing ships and in drawing blueprints for cupolas (i.e., a small dome on a circular or polygonal base). At the Battle of Lepanto in 1571, the Turkish Navy lacked improvements that had long been in use by the Italian and French navies. Two centuries later, Turkish artillery was still extremely primitive by Western standards. Worse yet, the dangers of lead poisoning had long been understood in Western Europe, but in Turkish lands lead remained a common ingredient in kitchenware for centuries (p. 46).

By the 17th century the Turkish writer, Katib Chelebi (d. 1657), lamented the continuing intellectual decay of the Islamic world:

> But many unintelligent people... remained as inert as rocks, frozen in blind imitation of the ancients. Without deliberation, they reject and repudiated the new sciences. They passed for learned men, while all the time they were ignoramuses, fond of disparaging what they called ‘the philosophical science,’ and knowing nothing of earth and sky… they thought contemplating the world and the firmament’meant staring at them like a cow (as cited in Reilly, 2010, p. 124).

Within a century of Mohammed's death, Islam created an empire that arguably possessed greater potential than any previous world empire (Jaki, 1990). Previous empires captured lands and peoples, but lacked continuity of culture and beliefs. Whereas, the Islamic empire was marked by a common faith, and in most cases, easily conquered and assimilated whole regions into Arab culture. The potential of an empire that possesses a common faith, common culture, and vast stretches of land has the potential for tremendous world influence. Yet, a philosophical and theological battle resulted in a sudden halt to scientific progress, which abruptly terminated scientific progress in the Islamic world (Carroll, 2007; Ferngren, 2002; Reilly, 2010). Conversely, Christian civilization and scholarship continued its expansion through the European continent, but not without significant difficulty (Crocker, 2001).

Missionary Linguistics

Written language is an indispensable prerequisite to education and science (Jaki, 1990). Christian missionaries, however, routinely encountered entire barbarian regions that were not only completely illiterate, but which lacked any form of written language whatsoever (Tarnowski, 1911). Typically the first phase of missionary evangelization was to learn, develop, and formalize the native language of the people. Thus, missionary linguistics provided the foundation for the spread of education and the eventual development and dissemination of science throughout the whole of Europe (Christianity.com, 2013).

The earliest surviving fragments from the Germanic region are fourth-century segments of Scripture produced by the missionary bishop, Ulfilus (310-383), who also devised the earliest version of the Gothic alphabet and written language. Similarly, the fifth century Bishop of Armenia, Mesrop (390-439), created the Armenian alphabet in response to the same disparity of language within Armenia (Christianity.com, 2013). Although, perhaps the most famous example of missionary linguistics is found in the work of two brothers, Cyril (827–869) and Methodius (826–885) of Thessalonica, known as the Apostles of the Slavs (Abraham, 1908).

Cyril devised the Slavic alphabet by using mostly Greek letters, some Armenian, and Hebrew letters, in conjunction with new letters he devised to express particular Slavic sounds (Christianity.com, 2013). The Cyrillic alphabet is still in use among the Slavic peoples of Russia, Bulgaria, and Serbia. Methodius followed up on his brother's work and before his own death in 885, applied his brother's newly devised alphabet to translate the entire Bible into the Slavic language (Abraham, 1908).

Missionaries were also instrumental in developing and regularizing the vernacular language of the barbarian Angles and Saxons, which later became the Anglo-Saxons of England (Hitchcock, 2012), the Polish language, as well as formalized written language in the Dutch Netherlands, Sweden, Scandinavia, the Baltic regions, Ireland, and elsewhere (Tarnowski, 1911). Thus, missionaries, mostly monks, regularized and developed grammar, punctuation, and the customary usage of the various European languages, which greatly accelerated the dissemination of education throughout the continent and prepared the foundation for the corresponding acceleration of science (Hitchcock, 2012).

The cultivation of education was made possible during and after the period known as the Dark Ages because of the persistence and arduous efforts of monks, who beginning in the fourth-century had opened a series of monasteries dispersed throughout Europe (Woods, 2005). The monasteries protected and preserved the various classical texts of Greco-Roman learning, which beginning in the medieval period, served as the basis of educational curriculum (Lucas, 2006). In fact, apart from the efforts of the monks, it is quite clear that the bulk or possibly the entire Greco-Roman classical learning tradition would have been lost during the Dark Ages (Paparella, 2008; Woods, 2005).

The Role of Monastic Learning and the Rise of Science

Perhaps the most significant series of events between the fall of the Roman Empire and the Renaissance, which may have been foundational to future scientific progress, concern the role of monks and the European monastery system (Woods, 2005). A crucial aspect of this research, as the research questions indicate, That monastic copyists (i.e., monks specifically assigned to copy ancient texts for preservation purposes) meticulously preserved the Scriptures is well documented (Lindberg, 1992), but it is less well known that monastic libraries and *scriptoria* (i.e., rooms set aside for copying of texts) also managed to preserve the bulk of the classical literature that survives to this day – even through centuries of invasions and turmoil (Paparella, 2008; Woods, 2005). Among the voluminous classical works the monastic copyists painstakingly preserved were important works by Plato, Aristotle, Ptolemy, Euclid, Cicero, Lucan, Pliny, Statius, Pompeius Trogus, Virgil, Ovid, Horace, Terence, Martial, Suetonius, and Sallust (Woods, 2005).

Classical works were not only preserved in monasteries, but were safeguarded in the great medieval cathedrals (Hitchcock, 2012; Woods, 2005). For example, Lindberg (2007) noted that the earliest existing copies of most Roman literature and scientific texts, as well as Latin translations of Greek texts, date from the Carolingian period (780-900 A.D.). The recovery and copying of books within the monastic and Cathedral Schools contributed to a wider dissemination of knowledge and education than had taken place within the Latin West for many centuries. This dissemination of knowledge through classical texts, particularly works on natural philosophy and mathematics, provided the foundation that would propel the sciences and enhance future scholarship for centuries to come (Hannam, 2011; Lindberg, 1992).

Some understanding of the sheer scope of monasticism in the wake of the collapse of the Western Roman Empire is indicative of the essential role monks played in the establishment of Western European culture, which included the initiation advancement of science (Crocker, 2001; Woods, 2005). The reputation of the Benedictine order was so great that at their peak they maintained 37,000 monasteries dispersed throughout Europe. By the 14th century, the Benedictines had produced 15,000 bishops, 7000 archbishops, 200 cardinals, 24 popes, and 1500 canonized saints (Woods, 2005). In comparison, in 2013 there were 5,223 bishops presiding in the Latin and Eastern churches of the Catholic Church (Living Bishops, 2013).

The monastic life was renowned for noteworthy scholarship and highly praised and respected by the whole of society (Hitchcock, 2012.; Paparella, 2008; Woods, 2005). Men and women from all levels of society were drawn to monasticism. Even the newly converted barbarians were attracted to monastic life, as is evidenced in such figures as Carloman, the King of the Franks, and Rochis, the King of the Lombards, who both surrendered their power and wealth to enter monastic life. The Benedictine's remarkable record of successes is further signified by their enrollment of 20 emperors, 10 empresses, 47 kings, and 50 queens (Woods, 2005).

Exchange of Knowledge

The monasteries represented a great network of communication across the European continent, wherein both scholarly learning and technological innovations were rapidly disseminated, as monks regularly traveled between monasteries for the purpose of sharing information (Woods, 2005). Due to their unprecedented access to knowledge, monks became the foremost experts in the various scholarly disciplines, as well as the practical arts (i.e., agriculture, animal husbandry, brewing, winemaking, beekeeping, cheese making, fishery management, metallurgy, marble extracting, salt mining, glass work, and clock making (Paparella, 2008). The shared technical innovations greatly increased efficiency and improved the conditions of life in and around the monasteries (Hannam, 2011).

A crucial aspect of the monastic system was their willingness and ability to share knowledge within the system of monasteries, which were oftentimes thousands of miles apart (Woods, 2005). As a result, the monasteries operated more efficiently and economically than was previously possible (Woods, 2005). For example, in ancient European monasteries archaeologists have found very similar water-powered systems employed to grind wheat, sieve flour, weave cloth, and tan hides (Paparella, 2008) – even at monasteries that were several thousands of miles apart (Woods, 2005). Another noteworthy example concerns the advancement of metallurgy by the Cistercian monks of Britain, who were particularly renowned for their technological sophistication (Woods, 2005). The University of Bradford archeo-metallurgist, Gerry McDowell, discovered evidence within a monastery in North Yorkshire, England, which demonstrated that the Cistercian monks had constructed a furnace to extract iron from ore with similar efficiency as is produced by a modern blast furnace. McDowell reported that the monks were on the verge of building a furnace for the large-scale production of cast iron, which was the key ingredient that centuries later helped launch the Industrial Revolution:

> One of the key things is that the Cistercians had a regular meeting of abbots every year and they had the means of sharing technological advances across Europe… They were poised to do it on a large scale, but by breaking up the virtual monopoly, Henry VIII effectively broke up that potential (as cited in Woods, 2005, p. 37).

Although the Cistercian monks had discovered how to build a blast furnace capable of producing cast-iron, the plundering of the English monasteries by Henry VIII had the effect of delaying the onset of the Industrial Revolution for two centuries (Woods, 2005).

The sharing of knowledge was not limited to technological information, as individual monasteries would often specialize in a specific branch of knowledge, such as, astronomy, mathematics, philosophy, metallurgy, philology, grammar, medicine, or agriculture (Paparella, 2008; Woods, 2005). Each of the various branches of learning were fostered within the monastic network. Although numerous examples could be recorded, a few will suffice to show the breadth of learning: (1) the monastery of St. Gall's school of painting and engraving; (2) lectures in medicine offered by the monks of St. Benignus at Dijon; and (3) the German monasteries, who were renowned for their lectures in Greek, Hebrew, and Arabic (Woods, 2005, p. 41).

Monastic schools, along with the Cathedral Schools founded by various bishops, laid the foundation for what would later become the universities (Hannam, 2011; Lindberg, 1992; Woods, 2005). Lucas (2006) observed that by at least as early as the eighth century, the Latin Church had come to monopolize learning, which took place in local churches and monasteries. Without the preservation of knowledge within the monasteries and cathedral libraries, the so-called Dark Ages, would have been significantly darker (Hannam, 2011; Paparella, 2008; Woods, 2005).

The various European schools were founded and administered by the Church, which for centuries had expressed a deep appreciation for knowledge and learning, and moreover, sought to synthesize all forms of knowledge (i.e., natural, philosophical, and theological). That is, in keeping with the tradition of the early patristic fathers, both the underlying order of the universe and the resolute belief in human rationality were consistently reaffirmed and disseminated through the European culture by way of education provided by the Church (Hitchcock, 2012; Jaki, 2000; Stark, 2003; Woods, 2005). Christianity's openness to the various forms of knowledge was and remains in stark contrast to the Islamic religion's resolute rejection of various forms of inquiry, aspects of natural knowledge (i.e., secondary laws of nature), and disinclination to accept the primacy of reason (Carroll, 2007; Jaki, 1990; Reilly, 2010).

If the only contribution to education the monasteries had been able to make during the destruction and turmoil pressed upon the European continent over the course of several centuries, was to teach their own how to read and write, that in itself would have been a monumental accomplishment (Woods, 2005). For example, in the 12th century BC, the Mycenaean Greeks suffered a catastrophic invasion by the Dorians and scholars maintain that the invasion resulted in three centuries of complete illiteracy, known as the Greek Dark Ages (1200 – 750 B.C.) (Dark Ages, n.d.). However, the monks' steadfast commitment to literacy and education ensured that Europe would not experience the same terrible fate that had befallen the Mycenaean Greeks. The Western Roman Empire collapsed, but the monks ensured that the light of learning continued to burn in the West (Woods, 2005).

Transitional Scholars within the Dark Ages

Knight and Lomas (2001) reiterated one of the most widely repeated myths that make up the commonly accepted narrative, which proposes that the Catholic Church was somehow responsible for the onset of the Dark Ages: "The establishment of the Romanized Christian era marked the beginning of the Dark Ages…when the lights went out on all learning…It lasted until the power of the Roman Church was undermined by the Reformation" (as cited in Woods, 2005, p. 3). Nonetheless, the historical record is clear that during the Dark Ages and beyond, the monks living within the European monastic system preserved, protected, studied, and disseminated the Greco-Roman intellectual tradition through their schools (Hannam, 2011; Jaki, 1990; Woods, 2005). Although Europe would not experience relative peace and security until the beginning of the Carolingian period at the beginning of the eighth-century (Paparella, 2008), during the intervening centuries, learning continued and was advanced by a series of important transitional scholars (Lindberg, 2002; Turner, 1912).

For example, the transitional scholar and bishop of Seville, St. Isidore (560–636), painstakingly compiled a twenty volume, systematized, condensed, collection of all the existing knowledge of his time (O'Connor, 1910). Fluent in the Greek, Latin, and the Hebrew language, Isadore quoted 154 different authors within the various disciplines. His twenty volume work was the most widely used textbook in educational institutions during the greater part of the Middle Ages and was reprinted ten times between 1470 and 1529. Later encyclopedic works drew heavily on Isidore's masterwork (Turner, 1912).

Another important transitional scholar was the English Benedictine monk, priest, historian, and Doctor of the Church, the Venerable Bede (672–735) (Lindberg, 1992). Bede is regarded as one of the most learned men of the early Middle Ages (Gilderhus, 2010). In keeping with the tradition of the monks, Bede highly esteemed the *quadrivium* studies (i.e., geometry, astronomy, arithmetic, and music). After compiling all of the astronomical knowledge available to him and all of the existing treatises on calendrics, he produced two textbooks on timekeeping and another on calendrics, which assisted him in formalizing a solid foundation for what came to be known as the science of computus (i.e., time reckoning, calendars, precise mathematics, and careful astronomical observation). The principles he developed for computus were eventually adopted throughout the West (Lindberg, 1992).

Lindberg (2002) aptly summed up the early Christian response to and engagement with natural philosophy during the transitional period: "…there were no institutions or cultural forces during the patristic period that offered more encouragement for investigation of nature then did the Christian Church" and argued that "…the presence of the Christian Church enhanced, rather than damaged, the prospects for the natural sciences" (p. 53). When Europe finally entered a long period of relative peace and security during the Carolingian era, education was regularized and made increasingly available across the continent, which significantly escalated the progress of science (Crocker, 2001; Hannam, 2011).

Education within the Carolingian Empire (741- 955 A.D.)

In the time between the fall of the Roman Empire and the Renaissance, Charlemagne's dynasty was instrumental in solidifying an educational foundation within which future scientific progress could flourish (Hannam, 2011; Lindberg, 1992). Since the collapse of the Western Roman Empire in 476 A.D., Christian missionaries had been undertaking the arduous task of cultivating relationships with and converting the more agreeable barbarian tribes to Christianity (Hannam, 2011). The culminations of those missionary efforts were recognized during the reign of Charlemagne (742–814), King of the Franks, and the first Holy Roman Emperor (Royal, 2006). Three factors converged during the reign of Charlemagne that were foundational to the advancement of science (Hannam, 2011). The first was the establishment of a general peace and stability across Europe, which arose after Charlemagne solidified his kingdom through more than 50 military campaigns (Crocker, 2001), through which France was established as the most powerful force in Western Europe (Hannam, 2011). The second factor that was foundational to the development of the natural sciences was the greatly accelerated search and procurement, preservation, and study of ancient works of natural philosophy. The third factor that decidedly facilitated the advance of science was the enactment of the Carolingian educational reforms, which significantly expanded and largely regularized educational opportunities throughout Europe (Hannam, 2011; Royal, 2006).

Charlemagne was himself literate and steadfast in his commitment to the extension of learning – both within his court and throughout the empire (Lindberg, 1992). His biographer noted that Charlemagne avidly pursued learning within the liberal arts and maintained a keen interest in astronomy. Charlemagne took the historic step of decreeing that the number of cathedral and monastic schools be increased throughout his empire (Hannam, 2011; Lindberg, 1992). In 789 it was recorded, "Let every monastery and every abbey have its school, in which boys may be taught the Psalms, the system of musical notation, singing, arithmetic and grammar" (Turner, 1908, para. 3). He also established monastic *scriptoria* (i.e., rooms set aside for copying of texts) within the imperial court itself, in addition to those already existing in the network of monasteries themselves (Brehier, 1910). Significantly, Charlemagne also invited many of Europe's most renowned scholars to join his court and later appointed several of these prominent scholars to important posts as bishops or abbots, from which they could enact his educational reforms (Lindberg, 1992).

Without question, the most significant scholar in Charlemagne's court was the Benedictine monk, Alcuin (735–804) (Brehier, 1910). Alcuin had been the headmaster of the school and library at York in England and was later appointed abbot of the monastery of St. Martin of Tours. At St. Martin of Tours he founded a school of calligraphy, which produced the most beautiful manuscripts of the Carolingian Age (i.e., a historiographical term signifying the rule of the Franks during the Early Middle Ages in modern France and Germany). Alcuin traced his scholarly influences back to the Venerable Bede (672–735) and was the central figure in a group of scholars who were interested in theological, ecclesiastical, scientific, and philosophical questions (Lindberg, 1992, Carolingian Reforms section, para. 5).

The sheer scope of the Carolingian educational reforms throughout the empire was astounding (Turner, 1908). The educational reforms in Germany were enacted by the Abbot of the monastery at Fulda, Rhabanus Maurus, who had earlier studied under Alcuin at Tours and developed a zeal for the classics and the cultivation of the sciences. Rhabanus Maurus administered educational activity in the schools of Solenhofen, Celle, Hirsfeld, Petersburg and Hirschau. Still later, he became Archbishop of Mainz, where he continued to sustain the reforms of the Carolingian revival. Because Germany had only recently assimilated into the culture and influence of Christian society, when at Mainz, Rhabanus chose to teach in the vernacular and was so renowned as an educator that he earned the title of "Teacher of Germany" (para. 4).

In France, following Alcuin's retirement to the Abbey of St. Martin at Tours, the Carolingian revival was taken up by the Bishop of Orleans, Theodulf (Turner, 1908). Before the close of the eighth century, education had been reformed in Southern Germany, Switzerland, Rheinau, Reichenau, and St. Gall. By early in the ninth century, Pavia and Bobbio in Northern Italy had been established and were flourishing. Schools had been founded at Utrecht, Liège, and St. Laurent in the Low Countries. Also, by the early ninth century, the revival of education had spread to Reims, Auxerre, Laon, and Chartres.

During the Carolingian era, education and scientific investigation were able to take hold and progress in the increasingly secure environment provided by the relative peace throughout Europe (Crocker, 2001; Royal, 2006). The Swift enactment of the Carolingian educational reforms can be attributed to the: (1) stability of the Carolingian empire; (2) the widespread, unifying Christian faith that was present in every city, town, and village throughout the empire, which provided the infrastructure necessary to preserve, organize, and disseminate knowledge; and (3) the normalization of language (i.e., broad use of Latin within scholarship, along with the written expression of formerly barbarian regional languages) throughout the realm (Woods, 2005). The Catholic Church provided the infrastructure required to cultivate learning and the sciences across the whole of the European continent (Hannam, 2011).

Scholarship Advanced by Pope Sylvester II (940 – 1003 A.D.)

The Carolingian educational reforms had established the infrastructure necessary for the advancement of scholarship (Turner, 1908). The bishop, Gerbert of Aurillac (940 – 1003 A.D.), who later became Pope Sylvester II, was a key transitional scholar in the period between the close of the, so-called, "Dark Ages" and the Higher Middle Ages (Hannam, 2011). Gerbert's scholarly reputation was such that he was commonly regarded as the most learned man in all of Europe (Woods, 2005). He received his first training in the monastery school of Aurillac in southern France and completed his studies at the school at Reims (Lindberg, 1992).

His breadth of knowledge was extraordinary and he was diligent in his pursuit of extant ancient manuscripts (Hannam, 2011). When Gerbert was offered money for his work, he requested that he be paid in manuscripts. He was renowned for his knowledge of Greco-Roman literature, mathematics, music, philosophy, medicine, astronomy, and theology (Lindberg, 1992; Walsh, 1915; Woods, 2005). Gerbert greatly enjoyed engaging in the slow correspondence of the time, wherein monks circulated letters to one another proposing complex mathematical problems or other types of academic questions for study (Hannam, 2011; Lindberg, 1992).

Early in his career, Gerbert was sent to Spain, wherein he was able to exchange mathematical and astronomical knowledge with Muslim scholars (Hannam, 2011; Lingberg, 1992). He learned the use of Arabic numerals while in Spain and without question, his most significant contribution to science was the introduction of Arabic numerals to Europe, which greatly improved the efficiency of the abacus in use at the time (Lindberg, 1992).

Gerbert was renowned for his knowledge of astronomy and he spent many hours building models of the universe (Hannam, 2011). He produced detailed instructions on how to make various astronomical apparatuses, such as spheres that displayed the locations of the stars in different sectors of the night sky. Gilbert is also credited with bringing an Arab astrolabe (i.e., an astronomical instrument that allows its user to tell the time from the positions of the stars or planets and carry out accurate astronomical observations) to European civilization (Hannam, 2011). He also wrote an instruction manual on the use of an astrolabe. The use of the astrolabe spread through Europe and in 1092 a monk named Walcher from England used an astrolabe to accurately predict and carry out an observation of a lunar eclipse, which subsequently enabled him to reconstruct the entire lunar calendar (p. 22).

Gerbert's biographer and student, Richer, noted Gerbert's content in the knowledge that his theological beliefs were consistent with his love of learning (Woods, 2005). Richer quoted Gerbert: "The just man lives by faith but it is good that he should combine science with his faith" (p. 23). Gerbert continuously emphasized that one should cultivate their faculty for reason, which he believed was endowed by God: "The Divinity made a great gift to man in giving them faith while not denying them knowledge…Those who do not possess it are called fools" (as cited in Woods, p. 23). Then in 999 he was the first Frenchman to be elected pope and took the name Sylvester II (Hannam, 2011).

In 999, Gerbert was the first Frenchman to be elected pope and his scholarly achievements at the close of the first millennium testify to the success of the Carolingian educational reforms, which provided the necessary foundation for the advancement of the natural sciences (Lindberg, 1992). His academic accomplishments include: (a) a mastery of the mathematical sciences which surpassed those of any European predecessor and which revealed a marked familiarity with Islamic achievements in mathematics and astronomy; (b) produced a continuous stream of correspondence related to such topics as, mathematics, astronomy, manuscript procurement and correction, requesting books on mathematics written by foreign authors, and the solicitation of books on astronomy composed by Muslim authors; (c) he offered instruction to companions and associates on solving various mathematical and geometrical problems; (d) left detailed instructions on the construction of spherical astronomical models and promoted their use in astronomical studies; (e) introduced the use of Arabic numerals to Europe and presented instruction in their use in multiplication and division; and the acknowledged inventor of the pendulum clock (Carolingian Reforms section, para. 16).

Gerbert's academic achievements should be viewed in light of the long-standing progression of science and scholarship within Christian Europe. Lindberg (1992) observed that Gerbert was a "remarkable scholar," who used his influence as a Church dignitary to advance science at the beginning of the second millennium (Carolingian Reforms section, para. 16). The educational foundation afforded by the Carolingian educational reforms engendered an additional advancement in higher education, which proved to be the final element required for marked and sustained scientific advancement within Europe (Grant, 2002; Hannam, 2011; Woods, 2005).

The Emergence of the Universities

The second research question herein, concerns the significant events related to faith and science that occurred in Europe between the fall of the Roman Empire through the Renaissance, which may have set the foundation for future scientific progress. Without question, one of the most significant historical developments between the fall of the Roman Empire through the Renaissance was the creation and expansion of the Church sponsored university system throughout Europe (Hannam, 2011; Jaki, 1990;

Lindberg, 1992; Wiker, 2011; Woods, 2005). The history of the emergence and development of the universities themselves can be viewed as a microcosm of the history and development of science because the two are so closely linked. The very concept of a 'university,' so essential for the rise and development of science, was conceived of and developed by the Catholic Church in the 12th century and was virtually a natural extension or consequence of the value the Church placed on scholarship and learning through the centuries (Grant, 2002; Woods, 2005; Pace, 1912).

The institution recognized today as the university had not existed in ancient Egypt, Greece or Rome, although higher learning existed in each (Cubberley, 1920; Grant, 2002; Lindberg, 1992; Lucas, 2006). The concept of a higher educational institution comprised of facilities, required courses of study, multiple specializations, examinations, and degrees, including the distinction between undergraduate and graduate studies, first arose in medieval Europe (Woods, 2005). Historian of science Michael Shank asserted: "Put succinctly, the Medieval period gave birth to the University, which developed with the active support of the papacy" (as cited in Wiker, 2011, p. 26).

Pope Gregory VII issued a proclamation in the year 1079, in which he declared that bishops everywhere were to have the *artes litterarum* (i.e., arts and letters) taught within their churches (Lucas, 2006). A century later in 1179, Pope Alexander III convened the Third Lateran Council, in which he and the 291 bishops in attendance decreed that because the Church is responsible for the welfare of the poor, it should see that they are not deprived of the opportunity to read. Schools were to be opened in every cathedral within Europe and funds were to be set aside to ensure that the clergy and "poor scholars" could be taught by a master free of charge (p. 37). Both edicts simply served to ratify practices that were already in place for some time (Lucas, 2006).

Universities were, contrary to the commonly accepted narrative, largely protected from outside interference (Woods, 2005). University faculties controlled the teaching enterprise and maintained autonomy (Lindberg, 1992; Walsh, 1915). Grant (2002) observed that academic freedom within medieval universities greatly enhanced rational inquiry and the advance of the natural sciences in particular.

Already by the beginning of the 13th century, dozens of Church sponsored universities were dispersed throughout Europe and by the time of the Protestant Reformation in the early 16th century, eighty-one universities were in existence (Cubberley, 1920; Hughes, 1892; Lucas, 2006; Woods, 2005). The University of Bologna grew out of the cathedral school in Bologna and was founded in 1150 (Lindberg, 1992). The University of Paris also grew out of the cathedral school and was established by 1200. Oxford University developed as a result of informal gatherings of masters and students and was well underway by the late 12th century (Hunter-Blair, 1911; Woods, 2005). The University of Bologna and the University of Paris served as the models by which all subsequent universities were patterned on (Cubberley, 1920).

European cities and nations petitioned the Church to found a university within their borders and Church sponsored universities were established in virtually every major city across Europe (Cubberley, 1920). Thus, early universities were established as far north as Sweden and Scotland off the North Sea; south in Spain and Portugal off the Mediterranean Sea, and in Italy between the Mediterranean and Adriatic seas. Further east, Poland and Hungary each boasted several universities, as did England and Ireland to the West (p. 219).

The cathedral schools offered course studies that encompassed the full spectrum of the seven liberal arts, which was a division of content used in ancient classification systems by noted encyclopedists and which continued to be used within monastic *scriptoria* (Lindberg, 1992; Woods, 2005). The university undergraduate curriculum included the *trivium* (i.e., grammar, rhetoric, and dialectic) and the *quadrivium* (i.e., arithmetic, music, geometry, and astronomy) (Lucas, 2006, p. 37).

By 2013 standards, the liberal curriculum content within Medieval universities is astounding and confirms a particular emphasis on the natural sciences (Woods, 2005). Some courses offered were grammar, humanities, natural sciences, theology, philosophy, medicine, jurisprudence, history, literature, mathematics, geography, prose, rhetoric, physics, metaphysics, logic, hydrostatics, hydraulics, aerostatics, pneumatics, elements of astronomy, magnetism, meteorology, geology, physiology, algebra, analytical geometry, differential calculus, trigonometry, inorganic and organic chemistry, physiology, cannon law, Sacred Scripture, Hebrew, Syriac, Arabic, Chaldaic, French, English, Greek, and Latin. The classic texts used during the course of a university education were equally impressive, encompassing works by authors as diverse as: Cicero, Ovid, Virgil, St. Chrysostom, Sallust, Livy, Curtius, Horace, St. Basil, Plato, Plutarch, Homer, Phocylides, Theognis, St. Gregory Nazianzen, Quintilian, Aristotle, Euclid, Socrates, and others. The majority of these classic texts survived the "Dark Ages," due to the labors of monks within monastic *scriptoria* rooms and were stored in both monastic and cathedral school libraries. A few other ancient texts were circulated throughout the European university system following the success of crusaders, who freed Spain from Moorish control in 1492 (Woods, 2005).

The early European universities were indispensable to the rise of science, as they placed great importance on the study of the natural sciences and great import was placed on mathematics and astronomy in particular (Grant, 2002; Stark, 2003; Woods, 2005). Astronomy was taught with skill and sophistication in many places and there is no doubt that the universities produced several highly proficient astronomers (Lindberg, 1992). No student emerged from the university without a thorough grounding in the natural sciences. The discipline of medicine was cultivated with its own faculty. The high degree of uniformity in curriculum also contributed to intellectual advancement in the various disciplines because scholars were regularly advancing the knowledge base. Even the language of scholarship was standardized. All scholarly writing was in Latin and all university courses were taught in Latin. The *ius ubique docendi* (i.e., right of teaching anywhere), along with a standardized language, fostered mobility and greatly enhanced intellectual exchange among scholars. Thus, for example, a scholar who earned a degree at the University of Paris could teach at Oxford without interference (Hannam, 2011; Lindberg, 1992; Woods, 2005).

Aristotle's works in logic, natural philosophy, and metaphysics, were essential components of the baccalaureate and Master of Arts degrees in medieval universities (Grant, 2002). The universities became the institutional base for Aristotelian teachings throughout Europe. As a result, a large class of professors were masters of

Aristotelianism, which they taught to virtually all of the students who passed through the university system (Hannam, 2011; Lindberg, 1992).

The extremely widespread transmission of knowledge across the whole of Europe was an entirely new phenomenon in the history of civilization (Woods, 2005). Knowledge had never been so uniformly communicated and dispersed through an entire continent before the establishment of the university system (Woods, 2005). For the first time in history, standardization, mobility, and intellectual freedom within higher education combined to fostered intellectual and professional unity on an international scope (Lindberg, 1992; Stark, 2003; Woods, 2005). Hannam (2011) observed, "the shared religion of Western Europe, as well as widespread knowledge of Latin, meant that Medieval scholars formed a single international intelligentsia that was more closely knit than it has ever been sense" (p. 130).

From the 12th century forward, every important discussion, hypothesis, theory, advancement, and achievement in any scientific discipline, originated within the realm of the monasteries or universities (Lindberg, 1992; Rait, 1918; Woods, 2005). Both monasteries and universities enjoyed Church and benefactor support, shared the language of scholarship (i.e., Latin), had access to virtually the same texts, and also had a means and by now long tradition of sharing scholarly information and advancements with one another (Hannam, 2011).

Through eight centuries of intermittent turmoil in Europe, the Church had managed a number of extraordinary accomplishments, which were essential for the emergence and advancement of science: (1) impart a theology that promotes the desire to discover the workings of the natural world (Jaki, 2000; Woods, 2005); (2) foster a devotion to natural philosophy and scholarship (Lindberg, 1992; Principe, 2011); (3) preserve the corpus of Western manuscripts through many turbulent and uncertain times (Lucas, 2006; Woods, 2005); (3) convert the barbarian invaders through time, which was necessary for sustained peace (Crocker, 2001; Woods, 2005); (4) devise new alphabets and forms of writing in regions of Europe that formerly possessed no familiarity with written language (Abraham, 1908; Tarnowski, 1911); (5) provide elementary education and scholarship throughout Europe (Hannam, 2011; Hess & Allen, 2008; Lindberg, 1992); (6) discretely acquire and share knowledge with their Islamic adversary (Hannam, 2011; Jaki, 1990); (7) standardize and unify the language of scholarship across a continent (Hannam, 2011; Lindberg, 1992); and (8) provide the final piece necessary for the successful cultivation of the sciences in the form of the university system (Crocker, 2001; Hannam, 2011; Principe, 2011; Rait, 1918; Stark, 2003). For the first time in history, the universities provided an efficient means for intellectuals to quickly communicate discoveries and advancements, which served to propel the advance of science in Europe (Lindberg, 1992, Woods, 2005).

Steady Progress in Science Begins

The central research question herein asked what insights may be learned through a comprehensive exploration of the historical relationship of faith and science, in light of current challenges confronting educators. It is the case that of all the ancient civilizations, the Greeks showed the most promise toward achieving authentic science (Jaki, 1990), but as is illustrated above, they too ultimately failed to abandon their pantheistic worldview for a paradigm utterly grounded in nature and unencumbered by animism (Woods, 2005). Christianity provided the necessary perspective on nature, due to a steadfast refusal to accept any aspect of pantheism or animism (i.e., specifically rejecting any allusion to an eternal, cyclical universe, and the idea that inanimate objects or any aspects of nature possess souls or are controlled by gods) (Augustine, 415/1982). In stark contrast to pantheism, from its inception, Christian theology proposed that an Intelligent Being created and sustains the universe through secondary causes, and moreover, intelligent human beings possess the capability to understand, at least in part, the workings of creation. In essence, the realization that the universe is intelligible proved to be necessary for the emergence of science within civilization (Jaki, 2000; Lindberg, 1992; Stark, 2003; Woods, 2005).

In terms of significant events related to the relationship of faith and science in Europe between the fall of the Roman Empire through the Renaissance, almost seven centuries had elapsed since the collapse of the empire in 476 A.D. and the establishment of the university system in Europe. However, much had been accomplished to rebuild civilization and advance learning in the intervening centuries (Crocker, 2001; Lindberg, 1992). The establishment of the university system in Europe proved to be the final element needed to produce previously unimaginable scientific progress. Between the collapse of the Roman Empire and the Renaissance, several key historical figures built on previous discoveries and/or disproved previous assumptions and their work was subsequently furthered by others – all in the context of the universities (Hess & Allen, 2008). The universities engendered exponential growth in the natural sciences, which has continued into the present (Hannam, 2011; Woods, 2005).

As noted above, in the context of this research it is not necessary to trace the history of every branch of science to demonstrate the historical connection of faith and science. Thus, two of the most significant developments in the history of science (i.e., the development of the heliocentric model and the theory of evolution), which took place between the Dark Ages and the Renaissance, will serve as examples of how science developed within the context of the Christian faith (Stark, 2003). Moreover, in the context of modern science curriculum, the majority of myths and half-truths concern the heliocentric model and evolutionary theory and those myths inevitably relate to the connection between faith and science (Pernoud, 1977/2000; Stark, 2003; Wiker, 2011). Thus, analysis of the key events in the development of these two scientific theories can uniquely inform the current debate concerning science curriculum and educational practice in 2014. Science did not develop and advance in any culture or religion outside of Christianity, but since the Age of Enlightenment, many have claimed that science managed to survive in spite of the Church's existence (Draper, 1874; White, 1896; Dawkins, 2006; Harris, 2004). Analysis of the development of the heliocentric model and evolutionary theory will speak to the questions surrounding how the various forms of Christianity helped further, and in some cases, obstructed the advancement of science.

First Practitioners of the Scientific Method

The first subquestion herein concerns what significance, if any, can be attributed to faith in the development of science, during the period between the fall of the Roman

Empire through the Renaissance. It follows then that the very persons responsible for first developing the empirical methodology and the period in which they lived are more than germane to this study. Modern scholars maintain that the foundations of the empirical scientific method (i.e., (a) the development of theory; (b) controlled experimentation; and (c) careful observation of results) were formulated by three scholars of the Higher Middle Ages: Robert Grosseteste (1175 – 1253), St. Albert the Great (1193 –1280), and Roger Bacon (1214-1294) (Lindberg, 1992; Walsh, 1915; Woods, 2005).

Robert Grosseteste (1175 – 1253) was the Bishop of Lincoln in England and the first Chancellor of Oxford University (Jaki, 1990). He was acclaimed as one of the most learned men of the Middle Ages (Urquhart, 1910). His commentary on Aristotle's *Posterior Analytics* was written in the 1220s and is one of the earliest attempts to deal seriously with Aristotle's scientific approach. Grosseteste's particular interest in Aristotle was in his rationalistic approach to science, as opposed to his integrated worldview derived from his philosophy (Hess & Allen, 2008).

Grosseteste was intimately familiar with Aristotle's *Physics, Metaphysics, Meteorology,* and biological works. He took part in translating Aristotle's various works on science and ethics and took part in seeing that the Oxford curriculum reflected those works (Hess & Allen, 2008). Grosseteste greatly influenced the works of his successor and eminent early scientist, Friar Roger Bacon (1220–1292), who was inspired by Grosseteste's scholarly example and mastery of the mathematical sciences in particular (Walsh, 1915).

Roger Bacon enthusiastically asserted that no person knew the sciences like Grosseteste because of his keen interest in mathematics, perspective, and scientific questions (Urquhart, 1910; Hess & Allen, 2008). Grosseteste produced several mathematical works, including a detailed analysis of the Julian calendar in use at the time, wherein he noted the necessity for changes to the calendar that would be implemented in the Gregorian calendar three centuries later (Walsh, 1915). He attempted to compile a classification of the various forms of knowledge and few among his contemporaries can have possessed a more encyclopedic range of knowledge. He wrote a textbook dealing with astronomy and the structure of the world, as well as scientific works on the nature of light, the movement of the tides, mathematics, comets, meteorology, optics, color, and the rainbow (Wiker, 2011).

Grosseteste was renowned for his preference for original sources and authorities, but most significantly, for his insistence on experimentation within the natural sciences (Hess & Allen, 2008; Urquhart, 1910) and made frequent references to *experimentum* within his works (Hannam, 2011). He produced an innovative approach to Aristotle's demonstrative syllogism, wherein he described controlled experiments that provided "…mathematically quantifiable and measurable data" (Hess & Allen, 2008, p. 16). Grosseteste was the first person in history to put the steps for performing a scientific experiment in writing (Woods, 2005). He practiced experimentation in his own work. For example, he conducted noteworthy experiments on angles of refraction in glass spheres, which led to the invention of spectacles in the century in which he lived and contributed to the eventual development of the telescope (Hess & Allen, 2008; Jaki, 1990). He was also an early proponent of the use of mathematics in the study of natural phenomena because he perceived the mathematical structure of nature (Hess & Allen, 2008). Four centuries later, his mathematical worldview ultimately led to Galileo's precise calculation of the rate of acceleration of balls rolling down inclined planes (p. 16).

St. Albert the Great (1193-1280)

The second scholar regarded as an initiator of the scientific method was St. Albert the Great (1193-1280) or Albertus Magnus (Woods, 2005). Albert was a Dominican friar of German birth, who was later elevated to Bishop of Regensburg, Germany (Hess & Allen, 2008, p. 17), at least in part due to his incredible depth and breadth of knowledge. He was later given the title "Universal Doctor of the Church" (Hannam, 2011, p. 84). St. Thomas Aquinas and Friar Roger Bacon were his two most famous students. Synan (1980) noted the underlying reason for Albert's immense interest in the natural sciences, "…although theology was his principal interest, he regarded natural philosophy as a complementary way of examining the created works of the First Cause" (as cited in Hess & Allen, 2008, p. 17).

Lindberg (2002) observed that Albert, and later Thomas Aquinas, provided the solution to the problem of faith and reason, which was desperately needed at the time, and which in no small way contributed to the advancement of science itself. The problem of faith and reason was at the forefront in the 13th century, as some scholars at the University of Paris, led by Siger Brabant, were echoing the most famous Muslin Aristotelian commentator, Averroes (Woods, 2005). Brabant was teaching that when properly pursued, philosophical and theological inquiry may lead in different directions and arrive at different "truths" (Ferngren, 2002, p. 68–69). Albert and Thomas successfully synthesized Aristotelian philosophy with Christian theology and concluded that faith cannot contradict reason. That is, they concluded that theological inquiry and natural philosophy can reveal different aspects of the same truth, but if properly pursued, cannot contradict one another (Carroll, 2007; Ferngren, 2002). If a contradiction arises, then the methodology proper to the natural sciences or proper to theology was not correctly followed (Woods, 2005).

It was very significant in the history of the development of science that Albert and Aquinas reasoned that faith and science cannot be at odds (Lindberg, 2002). Their conclusions regarding the synthesis of faith and reason precipitated the decision by the Bishop of Paris in 1270, which condemned 13 philosophical propositions taught by Siger Brabant and his followers (Lindberg, 2002). A total of 219 Aristotelian propositions were later condemned in 1277, which included several astrological propositions and several that described what God was incapable of doing. To be clear, the Bishop of Paris condemned several elements of peripatetic physics (i.e., Aristotelian physics) on theological grounds – not because they impeded the progress of natural philosophy. Nevertheless, the result was that the condemnations worked to open the realm of physics beyond the Aristotelian view that had been so firmly entrenched for more than a millennium (Hannam, 2011; Woods, 2005).

Albert is commonly regarded as the founder of Christian Aristotelianism in light of the fact that his commentaries were the first comprehensive interpretation of Aristotle's philosophy in the West (Lindberg, 1992). Although Albert profoundly respected and recognized the significance of Aristotelian philosophy, unlike most of his predecessors, he was always willing to discard any Aristotelian ideas that he considered false. For example, he asserted, "Whoever believes that Aristotle was a god, must also believe that he never erred. But if one believe that Aristotle was a man, then doubtless he was liable to error just as we are" (as cited in Kennedy, 1907, para. 4). Thus, in his *Summa Theologiae* he dedicated a lengthy chapter to addressing “the errors of Aristotle” (as cited in para. 4).

Albert was the first person in history to comprehensively analyze and explain the whole of Aristotle's works and grasping Aristotle’s physics was a necessary precondition to contesting his conclusions (Lindberg, 1992). Albert not only commented on and explained Aristotle's *Physics*, but did the same for every other Aristotelian book as well. His completed works on Aristotle filled twelve large volumes, containing more than 8,000 pages (Lindbergh, 1992). The standard edition of all of his collected works fills thirty-eight Latin volumes (Hannam, 2011).

Albert’s intellectual energy seems boundless considering that his non-theological writings make up less than half of his total output and include works on physics, geography, zoology, phrenology, chemistry (*alchimia*), astronomy, mineralogy, physiology, psychology, medicine, natural history, logic, and mathematics. His expertise in so many areas and associated ability to authoritatively speak on any explains the reason he was already referred to as "the great" during his own lifetime (Hannam, 2011; Lindberg, 1992; Kennedy, 1907).

In contrast to his Islamic contemporaries, Albert was careful to note that God customarily works through natural causes and that the natural philosopher's obligation is to investigate natural phenomena to their limit (Reilly, 2010). Even in his discussion of Noah's Flood, Albert was steadfast in his adherence to his own methodological prescription. He explained that because God uses natural causes to accomplish His will, the natural philosopher's task is to investigate those natural causes, but is simply not called to investigate the causes of God's will (Walsh, 1915).

Albert, like Grosseteste, opposed the Aristotelian notion of reason alone – apart from experiment – in the investigation of nature:

> All that is here set down is the result of our own experience, or has been borrowed from authors whom we know to have written what their personal experience has confirmed: for in these matters experience alone can give certainty (as cited in Walsh, 1915, p. 294).

He also noted, "The aim of natural science is not simply to accept the statements [narrata] of others, but to investigate the causes that are at work in nature" (as cited in Kennedy, 1907, para. 4). In keeping with his insistence on experience, he methodically observed plant and animal life firsthand and is regarded as the greatest field biologist of the Middle Ages. He corrected Avicenna's understanding on the reproduction of partridges on the bases of his personal observation of the process. Similarly, he revealed that he had visited a certain eagle's nest for six consecutive years (Lindberg, 1992).

Roger Bacon (1214-1294)

The third scholar credited with developing the modern scientific method is Roger Bacon (Lindberg, 1992; Walsh, 1915; Woods, 2005). Born in England, he studied at both Oxford University and the University of Paris (Hannam, 2011). During the course of his academic career he lectured on Aristotle's works on natural philosophy at the University of Paris and was eventually given a professorship at Oxford (Lindberg, 1992). In 1257, at the age of thirty-three, Bacon entered the Franciscan order and the Franciscans enthusiastically encouraged his scholarly interests, but after a short time he resigned his professorship at Oxford, in order to dedicate himself more fully to private study (Witzel, 1912).

Plato had supposed that concrete beings could be studied through the mathematical measurement of their behavior and because Franciscans order were proponents of Plato's philosophy, they were exceptional in mathematics (Hannam, 2011). Whereas, their Dominican counterparts were followers of Aristotle, who had generally neglected mathematics in his works, and as a result, Dominicans were generally less inclined toward the mathematical sciences (Hitchcock, 2012).

While on the faculty at the University of Paris, Bacon was one of the first to give lectures on the various aspects of Aristotle's natural philosophy (Lindberg, 1992). Bacon delivered lectures on Aristotle's *Metaphysics*, *Physics*, *On Sense and the Sensible*; most likely *On Generation and Corruption*, which deals with theory of matter, *On the Soul*, *On Animals*, and may have lectured on the work, *On the Heavens* (Resolution: Science as Handmaiden section, para. 3). During his time in Paris, Bacon became acquainted with

Cardinal Guy le Gros de Foulques, who later became Pope Clement IV (1265 – 1268). He was so impressed with Bacon's intellectual and spiritual insights that when he became pope, he asked Bacon to prepare a work on Christian reform. However, the pope's particular interest was in how the natural sciences were taught at Oxford (Walsh, 1915).

After initially trying to avoid producing the work for the pope, he produced his *Opus Minus* (i.e., *Lesser Work*) and *Opus Tertium* (i.e., *Third Work*), which were summaries of his *Opus Majus* (i.e., *Greater Work*) that he expanded by adding original material to concerning various aspects of the sciences (Lindberg, 1992, Resolution: Science as Handmaiden section, para. 3). Bacon sent his student with detailed instructions on how to present and explain the works to the pope, which included original, detailed drawings pertaining to physics (Witzel, 1912).

He sought to defend Christian truth by emphasizing the importance of studying Aristotle's natural philosophy, mathematics, and linguistics within the framework of Christian formation (Ferngren, 2002; Lindberg, 1992). In keeping with the long-standing Christian position on the relationship of faith and science, Bacon perceived that the natural sciences were a beautiful means of perceiving the handiwork of the Creator and expounded in detail as to precisely how the sciences can be of aid to the Christian faith (Hannam, 2011). Bacon reasserted the teachings of St. Augustine of the fifth-century, his great teacher St. Albert, and his contemporary St. Thomas Aquinas (Walsh, 1915), who all held that theology cannot oppose the natural sciences when both are directed and pursued to their proper end (Ferngren, 2002; Hitchcock, 2012; Lindberg, 1992). Bacon dismissed any alleged conflict between the sciences and Christian belief, as the result of either: (a) faulty translations of Sacred Scripture; (b) ignorant interpretations of Sacred Scripture; or (c) a misunderstanding of the complexity of the natural world (Lindberg, 1992), "and just in case these arguments failed, he shouted down his critics with a blast of rhetoric about the wonders of science" (Resolution: Science as Handmaiden section, para. 6).

Roger Bacon is renowned as a creative thinker and experimenter (Hannam, 2011). The Chinese had long before discovered explosive powder (i.e., black powder), but had only used it as a novelty in fireworks, but Bacon learned of this explosive powder from returning Franciscan missionary to China. Thus, the earliest reference to exploding powder in the Western world is found in Roger Bacon's, *Opus Tertium*, wherein he described firecrackers and envisioned the potential of the discovery:

> There is a child's toy of sound and fire made in various parts of the world with powder of saltpetre, sulphur and charcoal of hazelwood. This powder is enclosed in a packet of parchment the size of a finger. This can make such a noise that it seriously distresses the ears of men, especially if one is taken unawares, and the terrible flash is also very alarming. If an instrument of large size were used, no one could stand the terror of the noise and flash. If the instrument were made of solid material then the violence of the explosion would be much greater (as cited in Hannam, 2011, p. 140).

Bacon clearly envisioned how this Chinese novelty for children could be developed as a weapon (Hannam, 2011; Wash, 1915). Genghis Khan's (1162–1227) wars of conquest were recent memories for Europeans, so envisioning a weapon upon hearing of firecrackers was not completely unnatural – even for a Franciscan Friar. In his *Opus Magnum* he went further by asserting:

> That one may cause to burst forth from bronze, thunderbolts more formidable than those produced by nature. A small quantity of prepared matter occasions a terrible explosion accompanied by a brilliant light. One may multiply this phenomenon so far as to destroy a city or an army (as cited in Walsh, 1915, p. 322).

Bacon's futuristic speculations were not simply fancies, but were grounded in his appreciation of the sciences (Walsh, 1910; Walsh, 1915). He speculated that the force from explosions could one day be harnessed and used in extraordinary ways. He anticipated that engines would one day be produced, which could control explosions for the purpose of powering ships (Walsh, 1915), horseless carriages, and even flying machines (Hannam, 2011).

Bacon, also produced significant advancements in optics and anticipated the telescope more than three centuries before it was invented (Lindberg, 1992; Walsh, 1915). He reasoned that it is possible to construct a device that "from an incredible distance we might see the smallest letters…so also might we cause the sun, moon and stars to descend in appearance here below" (as cited in Hannam, 2011, p. 142).

He produced approximately eighty scholarly works that contain meticulously prepared drawings throughout, wherein he examined a variety of subjects in great detail, such as:

> …reflection of light, mirages, and burning- mirrors, of the diameters of the celestial bodies and their distances from one another, of their conjunction and eclipses; that he explains the laws of ebb and flow, proves the Julian calendar to be wrong…discusses and affirms the possibility of steam-vessels and aerostats, of microscopes and telescopes (as cited in Witzel, 1912).

Friar Bacon's accomplishments in natural philosophy far surpassed mere futuristic speculations (Lindberg, 1992; Walsh 1915; Woods, 2005). In his *Opus Tertium*, which he produced for the pope, Bacon very clearly defined the discipline of chemistry, including its investigative methods and limits:

> There is a science which treats of the generation of things from their elements and of all and inanimate things, as of the elements and liquids, simple and compound, common stones, gems and marble, gold and other metals, sulfur, salts, pigments, lapis lazuli, minium and other colors, oils, bitumen, and infinite more of which we find nothing in the books of Aristotle; nor are the natural philosophers nor any of the Latins acquainted with these things (as cited in Walsh, 1915, p. 134).

Like Grosseteste before him, Bacon utilized his substantial mathematical abilities and knowledge of astronomy to neatly address the inaccuracies of the Julian calendar (Walsh, 1915). He precisely calculated how much of an adjustment was needed to restore the year to its proper position, so that the calendar date would reflect reality. Calculations by Bacon and Grosseteste form the basis of the calendar that was later corrected by the Jesuit mathematician, Christophe Clavius, and promulgated by Pope Gregory XIII three centuries later (p. 323).

Bacon produced an accurate theory of lenses and taught the principal of the aberration of light (Walsh, 1915). Ancients had believed light to be instantaneous, but Bacon deduced that light travels at a definite rate of speed. Because the speed of light is so incredibly fast that it defies almost any possible observation from earth, it is all the more remarkable that he reached the conclusion that light travels at a constant rate of speed. In 1676, the Danish astronomer Romer, calculated the speed of light by observing the moons of Jupiter during different phases of the Earth's orbit, which demonstrated that the light from the moons took a definite amount of time to reach the Earth after their eclipse ended. But in the 13th century, Bacon did not yet possess the ability to observe the moons of Jupiter (p. 323).

As one of the three founders of the experimental method in science (Hess & Allen, 2008; Lindberg, 1992), in his *Opus Maius*, Bacon explained the superiority of the experimental method over Aristotle's insistence on pure reason – apart from experimentation:

> Without experiment, nothing can be adequately known. An argument proves theoretically, but does not give the certitude necessary to remove all doubt; nor will the mind repose in the clear view of truth, unless it finds it by way of experiment (Woods, 2005, p. 94).

The importance of the realization that experimentation and observation are essential to the study of the natural sciences can hardly be overstated. Modern empirical science rests on three elements: (1) the development of theory; (2) controlled experimentation; and (3) careful observation (Lindberg, 1992; Stark, 2003; Woods, 2005) and genuine empirical science is not possible if even one of those three elements is absent (Jaki, 1990).

The 13th century figures, Robert Grosseteste, Albert the Great, and Roger Bacon are the three founders of the experimental method in science (Hess & Allen, 2008; Lindberg, 1992; Woods, 2005). Thus, the 13th century marks the point in human history when the study of nature moved from a strictly intellectual or theoretical level, as practiced by the ancient Greeks, to a tangible level – for the first time grounded on experimentation. It is apparent from the historical record that successors in the various disciplines to Robert Grosseteste, Albert the Great, and Roger Bacon, used their newly devised empirical methodology to systematically build on their pioneering achievements.

Painstaking Steps Toward Heliocentrism

The history of the development of Heliocentrism: (1) is representative of how science developed as a discipline within Christian Europe (Hannam, 2011; Jaki, 1990; Lindberg, 1992; Stark, 2003); (2) speaks to the first subquestion herein, concerning significant events related to faith and science that occurred in the period between the collapse of the Roman Empire and the Renaissance; and (3) will dispel several myths and falsehoods that are repeated within modern science curricula (Pernoud, 1977/2000; Wiker, 2011). Great advancements were made in several scientific disciplines that ran concurrent with the progress of astronomy, such as, optics, medicine, metallurgy, anatomy, mathematics, and physics. But the story of astronomy's move from Ptolemy's long-accepted geocentric model of the solar system to Copernicus's heliocentric model is emblematic of the steady progress of empirical science during the Higher Middle Ages and into the Renaissance (Woods, 2005).

Many scholars consider Galileo, the most famous advocate of heliocentrism, to be the last of the Renaissance astronomers (History.com, 2013, para. 5). Nonetheless, the majority of discussions concerning the "Scientific Revolution" begin with Nicholas Copernicus (1473–1543), who is commonly credited with first conceiving of and postulating heliocentrism, in place of Ptolemy's geocentric theory (Hess & Allen, 2008; Stark, 2003). Copernicus is an excellent starting point for those who advance a "Scientific Revolution" thesis, which points to the sudden onset of modern science through an awakening of sorts, in lieu of a long, steady development over several centuries. However, as has been illustrated herein, Copernicus was the beneficiary of earlier discoveries in mathematics and astronomy, which enabled and led him to his greatest contribution: the development of the heliocentric model. In essence, as extraordinary as Copernicus' achievements were, they took place in an advancing scientific culture and were not a matter of chance, coincidence, or an inexplicable awakening (Hannam, 2011, Stark, 2003; Wiker, 2011; Woods, 2005).

Many very difficult scientific questions had to be contemplated and overcome before heliocentrism could even be logically considered (Stark, 2003). Moreover, after heliocentrism was proposed, precise astronomical observations and mathematical calculations had to be performed before it could ultimately be confirmed and confirmation came more than three centuries later. But first, before any meaningful progress could be achieved in the natural sciences, and physics in particular, Aristotle's physics had to be overcome, which proved to be very challenging because he was held in such high regard as a thinker (Hannam, 2011; Jaki, 1990; Lindberg, 1992; Woods, 2005).

Aristotle's ideas so permeated both the East and the West that rather than challenge his ideas, scholars tended to simply give him the benefit of the doubt (Grant, 2002; Hannam, 2011; Jaki, 2000; Stark, 2003). Islamic thinkers, for example, held Aristotle in such high regard that they never ventured beyond his ideas concerning the natural world. They meticulously copied and commented on his works, but did not challenge or add anything of significance to his teachings (Jaki, 1990). By contrast, in the early centuries of Christianity, scholars in the West began to question Aristotelian concepts in both his *Physics* and *Metaphysics*, which in time, enabled scientists to overcome the barriers to progress in physics that Aristotle had unwittingly put in place (Hannam, 2011; Jaki, 1990; Lindberg, 1992; Woods, 2005).

Overcoming Aristotle's Physics

The central research question herein enquires as to insights that may be learned concerning the historical relationship of faith and science. The contrast between Aristotle's metaphysical and theological beliefs with those of Christianity demonstrates how theological presuppositions act to shape ones worldview. Aristotle, as shown above, was immersed in a pagan culture and paganism's belief in a plurality of gods controlling aspects of nature is evident in many of Aristotle's conclusions regarding aspects and qualities of nature (i.e., physics). This section describes the vital role Christianity played in first opposing various aspects of Aristotle's assumptions regarding physics, and then, over time, correcting his errors in physics. Christianity's role in opposing and ultimately overturning Aristotle’s notions in physics was a tedious process, which primarily took place between the fall of the Roman Empire and the Renaissance, which addresses the first subquestion herein.

Several elements of Aristotle’s physics were such that their acceptance as facts unquestionably inhibited authentic empirical investigation of nature (Jaki, 1990). Yet, his ideas were so influential in the ancient and medieval world that in some cases it took scholars centuries even to object to Aristotelian concepts that could have easily be proven wrong (Hannam, 2011; Stark, 2003). Moreover, Aristotle arrived at his conclusions concerning physics apart from experimentation, instead relying solely on reason (Woods, 2005). Thus, for example, Aristotle reasoned that heavier objects fall faster than light objects and scholars simply accepted his assertion without bothering to test the idea. In short, Aristotle’s misguided notions concerning the workings of nature had to be discovered and supplanted before progress in physics could be made (Hannam, 2011).

In his honest effort to synthesize all knowledge, Aristotle formulated both his ethics and physics using the same thesis: all seeks what is best for it (Jaki, 2000). In terms of personal human acts, there seems to be great value in seeking what is good by recognizing absolute ideals, but when generally applied to the physical world, problems arise. If the first aim of physics were to ascertain the best, value-loaded position of matter, understanding the actual logistics of nature would be impossible. Thus, as a direct result of his thesis that all seeks what it best for it, Aristotle formulated erroneous laws of physics (Jaki, 2000).

Beyond his *Physics*, Aristotle's philosophical thought also posed serious impediments to Christian theology and the pursuit of the empirical sciences (Hess & Allen, 2008). It was necessary to overcome Aristotle's strong sense of what was possible and impossible in nature before science could progress (Grant, 2002). For example, he taught that nature was necessarily constrained to operate in specific ways, rather than other plausible ways and developed a theology consistent with that view – a theology which posed problems for the advance of science (Jaki, 1990). By applying his thesis that all things seek what is best, Aristotle proposed that the Unmoved Mover (i.e., God) caused the celestial bodies to move eternally through the heavens because of their love for the Unmoved Mover (Grant, 2002). He proposed that the heavenly sphere were in motion because they were seeking what is best. His assertions concerning the cause of the continual motion of the celestial spheres and all other motion (Grant, 2002), presented a serious impediment to progress in physics (Hess & Allen, 2008; Jaki, 1990; Jaki, 2000).

Another obstacle advanced by Aristotle was the assertion that a vacuum in nature is an absurdity and, in fact, an impossibility in nature (Grant, 2002; Stark, 2003). He had also voiced opposition to the use of mathematical formula to produce physical theorems and rejected the idea that it was possible to use deductions arrived at in one subject, such as mathematics, to prove something in another subject (Hannam, 2011). He also taught that no object could continue moving without some other object moving it (Hannam, 2011). An object being pushed along the floor will stop when a person stops pushing it, but a thrown ball is a very different case. When a ball is thrown it does not stop when it leaves the person's hand – even though it is not being “pushed” anymore. Aristotle reasoned that the air behind the ball pushes the ball forward. But again, experience reveals that the air is actually resisting the movement of the ball. Early scholars were not particularly convinced air pushed a flying ball, but they did accept Aristotle's law maintaining a moving object must be moved by something else, which made it difficult to conceive of alternative theories of motion (Hannam, 2011).

Eventually, scholars began to discern serious problems in Aristotle's natural philosophy and his law of motion was the first to be confronted (Jaki, 1990; Lindberg, 1992). The first significant challenge to Aristotle's laws of motion was not made by Galileo, as is commonly claimed, but was made by the sixth-century Christian scholar and Patriarch of Alexandria, John Philoponus (490-570 A.D.) (Hannam, 2011; Jaki, 1990; Lindberg, 1992). Philoponus proposed that the act of throwing an object impressed a force upon it, which was then responsible for moving the object forward, but that force was gradually used up or exhausted. Philoponus' suggestion maintained the Aristotelian dictum that a moving object had to be moved by something else, but in this case that "something" was an external force impressed upon it. Philoponus countered Aristotle's law with the following:

> If you let fall from the same height two weights, one of which is many times heavier than the other, you will see that the relative times required for their drop does not depend on their relative weights, but that the difference in the time taken is very small (as cited in Hannam, 2011, p. 172).

Philoponus's thoughts represent the first significant challenge to two key elements of Aristotle's physics: motion and the nature of falling objects (Hannam, 2011).

However, Europe was still in the midst of intermittent barbarian invasions so the delay in further advancement physics is understandable (Crocker, 2001; Woods, 2005).

Because the Christian view of creation is distinctly natural – not ethereal or otherworldly – Christian natural philosophers were the first in recorded history to view creation in purely natural terms (Jaki, 1990; Woods, 2005). Thus, over time, Christian theology successfully overturned Aristotle's: (a) imperishable, incorruptible heavens composed of *aether*, which (b) move in perfect circular motion because of their love for the Unmoved Mover; and (3) assertion that the celestial bodies are living beings with rational souls (Jaki, 2000; Stark, 2003). Moreover, Christian natural philosophers were the first to comprehend that the same physical laws govern both the celestial realm and this world, which was essential for the advance of the disciplines of physics and astronomy (Jaki, 1990; Jaki, 2000).

The naturalness of all of creation is a fundamental element of the Christian worldview and any remaining philosophical or theological views to the contrary were sufficiently overcome during the Higher Middle Ages (Stark, 2003; Woods, 2005). A most momentous achievement in scientific methodology took place in fourteen-century England, which forever supplanted Aristotle's resistance to the use of mathematics in the study of physics (Hannam, 2011).

Linking Mathematics and Physics

In keeping with the first two subquestions herein, which concern the historical relationship of faith and science in the period between the fall of the Roman Empire and the Renaissance, this section describes a 14th century breakthrough that changed the study of physics for all time. For the first time in history, scholars successfully linked the disciplines of physics and mathematics (Hannam, 2011). That is, notwithstanding Aristotle's earlier denunciation of the notion, scholars began to approach questions of natural phenomena using mathematics. The first co-mingling of mathematics and physics took place between 1325 and 1350 at Merton College within Oxford University. A succession of mathematicians, who came to be known as the Merton Calculators, became famous throughout Europe for their efforts in expanding the boundaries of physics. Their work was influential well into the 16th century and enabled the subsequent achievements of Copernicus, Galileo, Kepler, Newton, and their successors (p. 170). Some of their most important contributions to mathematics and physics were to distinguish between kinematics and dynamics, the investigation of instantaneous velocity, the formulation of the mean speed theorem, and demonstration of the essence of the law of falling objects.

The Archbishop of Canterbury, Thomas Bradwardine (c. 1290–1349), was the first of the Merton Calculators (Hannam. 2011). Bradwardine addressed the fundamental flaw in the Greeks pursuit of science, which was their unqualified reliance on reason alone to prove their theories, apart from experimentation (Jaki, 1990). Bradwardine departed from Aristotelian logic by proposing that mathematics was vital to the successful study of natural philosophy, whereby mathematics:

> …is the revealer of every genuine truth, for it knows every hidden secret and bears the key to every subtlety of letters. Whoever, then, has the effrontery to pursue physics while neglecting mathematics should know from the start that he

will never make his entry through the portals of wisdom (as cited in Hannam, 2011, p. 171).

Bradwardine reasoned that a mathematical formula would conclusively prove whether or not Aristotle's ideas on moving objects were correct, and significantly, Bradwardine also established a central element of modern scientific rationale: the formula had to be valid for all situations, whether for very small or very large numbers (Hannam, 2011). His first step was to try to determine the correct formula linking the force exerted on an object to its speed. After translating his work into modern notation, modern mathematicians noticed that Bradwardine had used a distinctive function called a logarithm. However, official histories of mathematics attribute the discovery of logarithms to John Napier (1550-1617), who lived three centuries later. In truth, Napier discovered logarithms independently, although Bradwardine and his colleagues had been using them centuries earlier (p. 172).

Bradwardine's achieved significant progress in the question of falling bodies by examining the hypothetical condition of an object falling in the absence of any air resistance (Jaki, 1990; Lindberg, 1992). He concluded, contrary to Aristotle, that heavy and light objects would fall at the same speed – even in a vacuum (Hannam, 2011).

The Merton Calculators were also the first to explicitly define the distinction between kinematics (i.e., mathematical representation of motion) and dynamics (i.e., mathematical description of the causes of motion) (Lindberg, 1992). The Merton scholars developed a conceptual framework and a technical vocabulary associated with kinematics, which involved the new concepts of velocity and instantaneous velocity.

Also, both were treated as mathematical concepts to which magnitude could also be assigned. The Merton group then began to reflect on qualities, their intensity, and their intensification, which led to a new distinction: the difference between the intensity of a quality and its quantity.

The various forms of analysis and discoveries of the Merton Calculators quickly spread through the European universities and by 1351, an Italian Franciscan priest, Giovanni de Casali, who had spent time at Cambridge, developed geometric representation of quality and its quantity (Lindberg, 1992). Later in the same decade, the eventual Bishop of Lisieux, Nicole Oresme (1325-1382), of the University of Paris, developed a much more sophisticated version of Casali's geometrical analysis (Duhem, 1911).

Oresme's theories and calculations were essential to the heliocentric theory that would later be advanced by Copernicus and furthered by Galileo, Kepler, and others in the coming centuries (Duhem, 1911). Oresme anticipated Copernicus by two centuries in his estimation that the Earth revolves daily, and in keeping with Ockham's razor (i.e., the simplest explanation is usually the correct one), offered a strong refutation of Aristotle's arguments to the contrary. Oresme surmised that it would be much more elegant for the Earth to rotate, then for the entire heavens to revolve daily. In arguing from a scriptural point of view, Oresme called to mind the authority of St. Augustine, who had asserted that any contradictions between the natural world and Sacred Scripture are only apparent. Oresme wrote:

> …the Sacred Scriptures wherein it is stated that the sun turns, etc. It might be supposed that here Holy Writ adapts itself to the common mode of human speech, as also in several places, for instance, where it is written that God repented Himself, and was angry and calmed Himself and so on, all of which is, however, not to be taken in a strictly literal sense (Duhem, 1911).

In response to Aristotle's assertion of an eternal universe, Oresme countered that the motion of the heavens had been started by the Creator, who imparted a quality of motion to the heavenly spheres at the moment of creation. Oresme's suggestion concerning the motion of the heavens was novel, but would be developed further in the upcoming centuries and become an essential component of the heliocentric model (Jaki, 1990). Copernicus turned to Oresme's work when formulating his heliocentric model and Galileo did the same in his efforts to promote and defend it (Duhem, 1911).

Although a Catholic bishop, Oresme, admonished those who would attribute the working of nature to supernatural forces or miracles – apart from secondary causes of nature:

> …there is no reason to take recourse to the heavens, the last refuge of the weak, or demons, or to our glorious God as if he would produce these effects directly, more so than those effects whose causes we believe are well known to us (as cited in Numbers, 2007, p. 41).

Oresme devised a form of geometrical representation, which was a forerunner of modern graphing techniques, in which the shape of the figure demonstrates the variations in the intensity of a quality over its subject (Lindberg, 1992). Oresme then went on to use geometry to represent motions of all varieties. He and his successors proceeded to use geometrical representation to illustrate and prove kinematic theorems that could be applied to uniformly accelerated motions. One essential theorem concerning uniformly accelerated motions is known as the "Merton rule," but is more commonly referred to as the mean speed theorem (Hannam, 2011, p. 171; Lindberg, 1992, Mathematical Description of Motion section, para. 13).

The Mean Speed Theorem

William Heytesbury (1313–1373) was another of the gifted Merton Calculators, who in 1335 published *Rules for Solving Logical Puzzles*, which described the most significant mathematical developments in 14th century physics (Hannam, 2011). Heytesbury devised a mathematical formula to describe what happens when a moving object accelerates at a constant rate (i.e., the mean speed theorem). Heytesbury recorded that “a body moving with constant velocity travels distance and time equal to an accelerated body whose velocity is half the final speed of the accelerated body” (as cited in Sant, 2014, para. 2).

Heytesbury’s mean speed theorem is central to physics because it describes the motion of any falling object of any weight, under the force of gravity (Hannam, 2011). Significantly, the mean speed theorem applies to motion in a vacuum, such as is found in outer space. Although many modern physics texts incorrectly attribute the main kinematical properties of uniformly accelerated motions to Galileo, the Merton Calculators had completely developed the theory almost three centuries before Galileo. Moreover, Casali and Oresme had also developed geometrical representations of the mean speed theorem that elegantly linked geometry and the physical world and the linkage of the two is a cornerstone of science. The Merton Calculators also demonstrated the theorem concerning the law of falling bodies centuries before Galileo, although Galileo is commonly given credit for that discovery as well (Lindberg, 1992).

The Theory of Impetus

Jean Buridan (1300–1361) was a priest and scholar, who spent his entire academic career at the University of Paris, where he was twice elected rector (Hannam, 2011). It was Buridan's conviction that the principles of science should be accepted when they are observed to be true and never exhibit a counterexample. In keeping with the Christian tradition, he proposed that the pursuit of physics was to explain things as they normally appear. Buridan believed that miracles can occur, but he proposed that it is the task of physics to study natural phenomena "assuming the ordinary course of nature" because "it is evident to us that every fire is hot and that the heavens are moved, even though the contrary is possible by God's power" (as cited in Hannam, 2011, p. 178).

In studying Aristotle's physics, Buridan utilize the scholastic method Aquinas had perfected, which was popular at the time (Grant, 2002; Jaki, 2000). In his *Questions on Aristotle's Book on the Heavens*, Buridan proposed and answered the following questions: "whether there are several worlds"; "whether the sky is always moved regularly"; "whether the stars are self-moved or moved by the motion of their spheres"; "whether the Earth always rests in the middle [or center] of the world"; and several other questions that dealt with the celestial regions (Grant, 2002, p. 38).

Buridan examined and ultimately rejected the Aristotelian concepts of natural and violent motions (Hannam, 2011). Aristotle had proposed that natural motion is a condition wherein objects essentially seek their best, value-loaded position and fall because of their love for the center of the Earth. Whereas, violent motion was anything out of the ordinary which disrupted natural motion, such as, picking up a stone (Jaki, 1990). Aristotle also taught that heavenly objects move in perfect circles.

Buridan countered Aristotle's laws of motion by formulating an alternative theory that is based on the concept of "impetus," which had first been suggested eight centuries earlier by John Philoponus (Hannam, 2011; Jaki, 1990; Lindberg, 1992). In sharp contrast to Aristotle, Buridan suggested that air did not push a thrown ball forward after it had left the hand, but rather, the motion of the hand imparts a quality or force upon the ball, which he called impetus. He noted that more impetus was required to heave a heavy rock than was required to toss a small pebble the same distance. Moreover, faster moving objects possess more impetus than slow moving objects. Buridan then reasoned, "…that impetus must be a quality whose magnitude was proportional to both weight and speed" (Hannam, 2011, p. 179).

Buridan also calculated that a falling object will gain impetus as it speeds up and impetus is expended as it is subjected to air resistance (Hannam, 2011). He then realized the radical implications and enormous potential of his theory, as he recorded: "Impetus would last forever if it were not diminished and corrupted by an opposing resistance or a tendency to contrary motion" (Hannam, 2011, p. 179). Buridan realized that an object in a vacuum would continue to move forever or until it encountered contrary motion. He reasoned further that if the heavens were a vacuum, impetus would explain the continuous orbits of the planets in the heavens. By discovering the force responsible for continual movement of the heavenly spheres, Buridan had solved a problem that had confounded humankind from the earliest times.

Natural philosophers had been trying to explain the motion of the heavenly bodies in context of Aristotle's law of motion (i.e., everything that moves must, by necessity be moved by something else) (Hannam, 2011). Christian theologians had repeatedly condemned the Greek notion that the planets possess some sort of soul that accounts for their movement (Hannam, 2011). Nonetheless, in the absence of a natural explanation, some medieval philosophers had speculated that God had assigned angels to move the planets; and then Buridan discovered that impetus is the force responsible for moving the planets through the heavens:

> In the celestial motions, there is no opposing resistance. Therefore, when God, at the creation, moved each sphere of the heavens with just the velocity he wished, he then ceased to move them himself and since then those motions have lasted forever due to the impetus impressed on the spheres (as cited in Hannam, 2011, p. 180).

Consequently, 300 years before Newton, Buridan came very close to describing inertia when he recognized that the planets would keep moving if there was no opposing force to act upon them (Hannam, 2011). More work still had to be done in order to correctly formulate inertia as it is understood today. However, Buridan's articulation of impetus, in opposition to Aristotelian physics, laid the foundation for the emerging discipline of mechanics, which drove astronomy forward. Buridan had incisively challenged and overturned a crucial element of Aristotelian physics, which facilitated the further advance of astronomy and had the effect of finally freeing natural philosophers from the confines of Aristotelian physics (Impetus Theory, n.d.).

Buridan took another decisive step toward the heliocentric model by giving serious consideration to the idea that the Earth undergoes diurnal (twenty-four hour) rotation (Hannam, 2011). Although, he never supposed that the Earth orbited the sun. To Buridan, the Greek notion of a stationary Earth and a complete rotation of the heavens, suggested an inelegant design. He suggested that the simple rotation of the Earth itself would be much more efficient. Nonetheless, Buridan insisted that even elegance would have to be checked with the empirical facts in order to determine how God had actually designed the cosmos.

The Greek astronomer, Ptolemy, had speculated that if the Earth were rotating it would cause a tremendous wind because the atmosphere would be stationary, while the Earth turned (Hannam, 2011). Buridan countered that the atmosphere must be rotating along with the Earth, so no great wind is produced. Then, however, Buridan mistakenly resorted to Aristotelian physics and reasoned that if the Earth is rotating, an arrow shot straight into the air should fall behind the shooter. Later, Buridan’s most brilliant student, Nicole Oresme, correctly analyzed and answered the problem concerning the Earth’s rotation and the arrow.

Systematic Dissemination of Knowledge

Knowledge only retains its value when shared. The means developed by which knowledge was systematically communicated will be addressed in this section, as it demonstrates the unique, historical connection of faith to science. That is, the relationship of faith and science is shown in the understanding that the institutional Church developed the mechanisms by which knowledge and learning spread throughout the European continent.

The works of the both the Merton Calculators in England and the natural philosophers of the University of Paris were rapidly dispersed throughout the European universities, along with other scholarly developments (Hannam, 2011). Several factors aided in the timely dissemination of knowledge: (1) a standardized language of scholarship existed (i.e., all scholarly works were penned in Latin and all lectures were delivered in Latin) (Christianity.com, 2013); (2) the standardization of curriculum, degrees, and teaching requirements within the universities encouraged free movement throughout the continent by renowned scholars (Lindberg, 1992; Woods, 2005); (3) a common cultural identify throughout the whole of Europe, which was largely the result of a shared faith that permeated every aspect of life within Western culture (i.e., Christendom) (Crocker, 2001); and (4) a relative peace within Europe, as the barbarians had yielded, although Islamic invasions were a continuing threat to European security during the Middle Ages (Woods, 2005).

An example of the dissemination of new knowledge through the universities is apparent in the case of Albert of Saxony (1316–1390) , who was a German scholar who came to teach in the school of philosophy at the University of Paris, where both Buridan and Oresme were professors (Hannam, 2011). Between his own teaching and research, Albert studied under Buridan, and successfully overcame another Aristotelian error in physics (Jaki, 1990).

Aristotle had implied that a cannonball shot from a cannon would fly forward until the air stopped pushing it forward and then it would fall straight to the ground at a 90° angle (Hannam, 2011). Albert saw that this defied commonsense, so he drew a diagram showing a ball shooting out of the barrel of the gun in a straight line, but then curving gently to the ground as it exhausted its impetus; thereby producing the earliest representation of a curved trajectory. His analysis essentially highlighted and clarified Buridan's previously proposed theories (Jaki, 1990). Albert published his work, which analyzed trajectories in light of both Buridan's and Oresme's previous research (Hannam, 2011).

Ultimately, Albert followed Buridan as rector of the University of Paris (Hannam, 2011). He then received permission from the pope to found a new university in Vienna before being appointed Bishop of Halberstadt. As an academic he spread the work and achievements of Buridan far from the confines of Paris, France. The Merton Calculators, Buridan, Oresme, Albert of Saxony, and their immediate predecessors, shared information and built on the research of others as they increasingly exposed and overturned Aristotle's errors in *Physics*, which provided the groundwork for additional astronomical theorizing to come (Jaki, 1990). Essentially, the indispensable mechanism by which new knowledge and learning were shared and communicated (i.e., the Church sponsored university system throughout Europe) was not only in place and established by the 14th century, but was thriving. Nonetheless, progress in science was fundamentally interrupted and not immediately taken up and advanced by successors because very soon, Europe was overwhelmed by the plague.

Sudden Interruption of Medieval Science

Buridan and Oresme mark the high point of natural philosophy in the 14th century, as they developed some of the key concepts of modern empirical science (Hannam, 2011). But soon, the deadly incursion known as the Black Death, swept through the European continent. Crowded university cities were particularly hard hit because as students tried to flee from the plague, they spread it to their homes, cities, villages, and monasteries. Gottfried (1983) reported that at least forty percent of the European population succumbed to the disease during the first four years. The initial epidemic of the plague subsided in 1350, but returned in full force ten years later and was intermittent for the next three centuries. The brilliant Merton Calculator, Thomas Bradwardine, was killed in the first wave in 1349 and John Buridan succumbed to the disease in the second (Hannam, 2011). Soon, however, progress in physics resumed with the work of a cardinal of the Church, who anticipated Copernicus's heliocentric model and in so doing, advanced astronomy further (Duhem, 1911).

Nicholas of Cusa (1401-1464)

Another significant historical figure whose life and works speaks to the interlinked nature of faith and science, leading to the time of the Renaissance, was a German born philosopher, mathematician, astronomer, and cardinal of the Church, Nicolas of Cusa (Hess & Allen, 2008). Nicholas studied at three different universities and published several mathematical works (O'Connor & Robertson, 2010). His mathematical expertise led him to conclude that a perfect circle is not possible in the universe, which negated yet another Aristotelian-Ptolemaic premise and anticipated Kepler's elliptical planetary orbits. Cusa also contributed the mathematical concept of the infinitesimal and used concave lenses to correct myopia (Hess & Allen, 2008).

Nicholas acquired an interest in astronomy and in 1444 he purchased sixteen books on the subject, a wooden celestial globe, a copper celestial globe, and a variety of astronomical instruments, including an astrolabe (O'Connor & Robertson, 2010). Gerbert (i.e., Pope Sylvester II) had acquired the astrolabe from Muslim scholars more than four centuries earlier (Hannam, 2011). After studying the works of Buridan, Oresme, and several other scholars, Nicholas developed a speculative cosmology, in which he proposed: the earth orbits the sun; stars are other suns; and other worlds – even inhabited worlds – orbit the other suns (O'Connor & Robertson, 2010). Nicholas's speculative cosmology reflected the discernible progress toward the heliocentric model for which the pieces were by now virtually in place.

Characteristic Copernicus Narrative

This first subquestion in this dissertation concerns the most significant events related to faith and science that transpired in Europe between the collapse of the Roman Empire and the Renaissance, which may have set the foundation for future scientific progress. The development of the heliocentric model is arguably the most significant of such events for the reason that it ultimately supplanted Ptolemy's long-accepted geocentric model and because, at that time, some Christians believed geocentrism was depicted in the Bible itself. Copernicus's heliocentric model initially garnered much praise, but unlike the scientific discoveries previously described herein, the model was later severely criticized by a large segment of Christianity because of the timing of its publication – less than fifty years prior to the start of the Protestant Reformation (Stark, 2003). Moreover, arguably more myths surround the development and promotion of the Copernican model – myths still taught in Western science classrooms in 2014 – than any other aspect of science education (Jaki, 1990; Woods, 2005).

According to many popular histories and accounts authored by conflict theorists, Nicholaus Copernicus floundered his way through the dark recesses of the medieval world and almost by sheer accident, determined that the earth revolves around the sun (Hess & Allen, 2008; Stark, 2003; Woods, 2005). One E.C.J. Morton expressed it this way:

> Copernicus cannot be said to have flooded with light the dark places of nature – in the way that one stupendous mind subsequently did – but still [Newton], as we look back through the long vista of the history of science, the dim Titanic figure of the old monk seems to rear itself out of the dull flats around it, pierces with its head the mists that overshadow them, and catches the first gleam of the rising sun,… (as cited in Cubberley, 1920, p. 387).

AD White (1896) described Copernicus as an isolated Catholic cleric and observer of the heavens, who somehow apprehended that the earth revolves around the sun:

> [A]t length appeared, far from the centres of thought, on the borders of Poland, a plain, simple-minded scholar, who first fairly uttered to the modern world the truth – now so commonplace, then so astounding – that the sun and planets do not revolve around the earth, but the earth and planets revolve about the sun (p. 121).

Similar accounts of the development of heliocentrism have simply become the accepted narrative and are commonly repeated because earlier accounts are uncritically relied upon (Numbers, 2009; Pernoud, 1977/2000; Wiker, 2011; Woods, 2005). Consider the following quote from a book published by Princeton University Press in 1997, which once again reiterates the claims that after the fall of Rome the Church discouraged the development of science for a 1,000 years and that a high regard for Scripture led to the trial of Galileo:

> …to illustrate the point that the Christian religion developed on the basis that the Gospel was the primary source of guidance and of truth and was inviolate. This commitment to Holy Scripture was, and still is, the fundamental basis of Christianity, but there is no doubt that it was a discouragement to scientific endeavors and these languished for a thousand years after the military fall of Rome. During that time, possibly because the Gospel was based on ancient writings, other ancient works of a non-religious character, including the writings on science by the ancient Greeks, also came to be regarded as inviolate. These factors were to lead to one of the most unfortunate events in the history of Christianity and science – the trial of Galileo (Wilson, 1997, p. 45).

Stark (2003) noted that the most often repeated elements of the heliocentric narrative are that the Catholic Church did all it could to suppress the idea, and moreover, heliocentrism only survived due to the more enlightened auspices of Protestantism.

The facts surrounding Copernicus and the development of heliocentrism do not begin to support the narrative (Hess & Allen, 2008; Lindberg 2007). For example, the first of White's (1896) falsehoods is that Copernicus was a mere "simple minded scholar" (1992; Stark, 2003; Wiker, 2011; Woods, 2005). In point of fact, Copernicus received a superb education, spoke five languages, and was a keen beneficiary of the mathematical-astronomical heritage of the Church-sponsored University system that had already been in place for more than 300 years. He excelled in mathematics and astronomy at the Jagiellonian University of Kracow, which was one of the most renowned universities of the time.

Copernicus studied a variety of theorists including, Ptolemy, Euclid, Sacro-bosco, and Regiomontanus and he continually complemented his studies with personal observations (Woods, 2005). For example, while in Kracow, he observed the comets of 1491 and 1492, as well as four lunar and solar eclipses within the next two years (Hess & Allen, 2008). He earned his first degree at the University of Krakow and then studied for an additional seven years combined at the University of Bologna and the University of Padua, respectively. His studies culminated with a Doctorate of Canon Law degree from the University of Ferrara (Stark, 2003). His mathematical prowess, particularly in the area of spherical trigonometry, is evidenced in the fact that for many centuries after the publication of his *De revolutionibus,* only a handful of scholars could penetrate the complexity of his calculations (Woods, 2005). Moreover, evidence of the high regard the Church had for Copernicus and his mathematical prowess, lies in the fact that his calculations were used in the formulation of the Gregorian calendar of 1582 (Hess, & Allen, 2008).

The second mischaracterization by White (1896) is that Copernicus developed the concept of heliocentrism alone – apart from any scholarly influences – "far from the centres of thought" (p. 121). In truth, Copernicus thrived in an educational and theoretical environment, wherein his scholastic professors taught him the foundational ideas that directly led to the heliocentric model (Wiker, 2011). The heliocentric model was gradually formulated in the course of the preceding two centuries by a line of scholars and theorists, who were greatly celebrated at the time, but are now largely forgotten. For all his genius and weight of his contributions, Copernicus should be understood as having taken the next logical next step toward heliocentrism, rather than as a lone theorist. Robert Grosseteste, St. Albert the Great, Roger Bacon, The Merton Calculators, John Buridan, Nicole Oresme, Nicholas of Cusa, and other scholastics had already set the parameters of empirical science and advanced conclusions about mechanics that were so well formulated that Copernicus simply accepted their authenticity and did not even attempt to improve upon them (Stark, 2003).

The third misconception of the recurring narrative is that heliocentrism was saved from the clutches of the oppressive Catholic Church by the more enlightened Protestants (Stark, 2003). In reality, Copernicus dedicated his book to the reigning Pope Paul III and not only did the Church not voice any objections to heliocentrism for almost another century, but the pope was extremely captivated by Copernicus's theory (Woods, 2005). News of the Copernican system quickly spread and became very well-known in scholarly circles. Significantly, for close to a century, the Church held no official position on heliocentrism and free debate prevailed among those able to comprehend the complex mathematical arguments *pro* and *con* (Godwin, 2008). Eventually, however, following the onset of the Protestant Reformation, the Church was forced to act in response to Protestant pressure arising from the claim that the Catholic Church disregarded Sacred Scripture (Hess & Allen, 2008; Wiker, 2011; Woods, 2005).

Early Life and Career of Copernicus

Mikolaj Kopernik (1473–1543) (i.e., Nicholaus Copernicus), was born in Torun, Poland on February 19, 1473 (Hess & Allen, 2008). Copernicus was a Doctor of Canon Law and although it is uncertain whether he was ordained a priest, he did take minor orders and held the position of church canon of Frombork Cathedral, where he engaged in Church administration for more than forty years (Hess & Allen, 2008; Wiker, 2011). His position of church canon provided him with financial independence and the leisure to engage in his personal interests, which included practicing medicine, painting, and astronomy (Walsh, 1915). His principle interest and life's passion was astronomy and in 1510 he built an observatory in a tower near the Frombork Cathedral (Hess & Allen, 2008).

Copernicus originally sought to improve upon the predictive accuracy of astronomy and first turned to the Ptolemaic system (Hess & Allen, 2008; Woods, 2005). Gradually, however, he turned his attention to an alternative model that proposed a moving earth, which had originally been suggested in antiquity and more recently considered by Buridan, Oresme (Duhem, 1911) and Nicholas of Cusa (O'Connor & Robertson, 2010). In 1514, Copernicus presented a six page outline of his system in the form of an unpublished, hand written draft, entitled, *Commentariuolus* (*Little Commentary*), which was widely circulated among his students (Rabin, 2010).

In his *Commentariuolus* Copernicus challenged established tradition by proposing three kinds of terrestrial motion, which he continued to develop and elaborate on over the next 25 years: (1) real diurnal (24-hour) rotation of the Earth to account for the apparent diurnal rotation of the heavens; (2) annual revolution around a stationary Sun to account for the solar year; (3) motion in declination to account for the procession of the equinoxes (i.e., a very slow westward shift of the equinoxes) (Hess & Allen, 2008, p. 35).

Copernicus's system entailed seven basic assumptions, which he referred to as axioms in his *Commentariuolus* (as cited in O'Connor & Robertson, 2002, para. 16):

1. There is no one centre in the universe.
2. The Earth's centre is not the centre of the universe.
3. The center of the universe is near the sun.
4. The distance from the Earth to the sun is imperceptible compared with the distance to the stars.
5. The rotation of the Earth accounts for the apparent daily rotation of the stars.
6. The apparent annual cycle of the movements of the sun is caused by the Earth revolving around it.

7. The apparent retrograde motion of the planets is caused by the motion of the Earth from which one observes.

Copernicus was acclaimed as a mathematician and astronomer and was enthusiastically received in ecclesiastical circles in Rome (Woods, 2005). For example, he was summoned to the Fifth Lateran Council (1512–1517) as a consultant on calendar reform. In 1531, Copernicus prepared an outline of his heliocentric model that drew substantial interest and attention. The interest was so great that in 1533, Pope Clement VII requested his secretary, Johann Albert Widmanstadt, to prepare a public lecture at the Vatican on the Copernican system, which the pope and several cardinals attended. The pope remained fascinated with Copernicus's model (p. 68). Three years later, in 1536, Widmanstadt gave another lecture on the Copernican system to Nicholas Schonberg, the Cardinal of Capua, who subsequently wrote to Copernicus, urging him to publish his theory:

> Some years ago word reached me concerning your proficiency, of which everybody constantly spoke. At that time I began to have a very high regard for you, and also to congratulate our contemporaries among whom you enjoyed such great prestige. For I had learned that you had not merely mastered the discoveries of the ancient astronomers, uncommonly well, but had also formulated a new cosmology. In it you maintain that the earth moves; that the sun occupies the lowest, and thus the central, place in the universe; that the eighth heaven remain perpetually motionless and fixed; and that, together with the elements included in its sphere, the moon, situated between the heavens of Mars and Venus, revolves

> around the sun in the period of a year…Therefore with the utmost earnestness I entreat you, most learned sir, unless I inconvenience you, to communicate this discovery of yours to scholars, and at the earliest possible moment to send me your writings on the sphere of the universe together with the tables and whatever else you have that is relevant to this subject…If you gratify my desire in this matter, you will see that you are dealing with a man who is zealous for your reputation and eager to do justice to so fine a talent (Schonberg, 1536, para. 7).

Copernicus did not relent for another seven years, but finally published his theory at 70 years of age (Gassendi & Thill, 2002). He was extremely cautious to the point that he rechecked his figures for half of his lifetime before finally publishing in 1543. In his preface and dedication to Pope Paul III, he explained his hesitancy in publishing, "The scorn which I had to fear on account of the newness and absurdity of my opinion, almost drove me to abandon a work already undertaken" (Copernicus, 1543, para. 5).

Copernicus's rehabilitation and development of the ancient heliocentric hypothesis forever changed astronomical perspective, but much work remained to be done. In fact, heliocentrism was not confirmed for another three centuries (Hess & Allen, 2008). Lindberg (2007) noted that Copernicus was well aware heliocentrism had originally been proposed in the third century BC by Aristarchus, as well as by the Pythagoreans Philolaus and Ecphantus. He was also intimately familiar with the classical arguments against heliocentrism, which were so strong that geocentrism had prevailed since antiquity (Hess & Allen, 2008; Lindberg, 1992).

Copernicus masterfully refuted Ptolemy's three principal arguments against a moving Earth in the following manner (Hagen, 1912):

- Ptolemy reasoned that a disastrous centrifugal force would be created on the surface of the earth. Copernicus argued that a far greater centrifugal force must be present in the outer planets and the fixed stars if they revolved around the earth, due to the incredible speed required for their rotation.
- Ptolemy held that the resistance of the atmosphere would cause a tremendous wind that would sweep away every object from a moving earth. Copernicus relied on the argument developed in the 14th century by Buridan, noting that each planet condenses and carries its own atmosphere.
- Ptolemy had argued that significant changes would emerge in the shape of the constellations when viewed from opposite points of the earth's orbit. Copernicus correctly reasoned that the stars are so distant that their terrestrial orbits are comparatively too small to reveal any effect in the instruments then available.

The classical arguments were based on both common sense experience and astronomical observation (Hess & Allen, 2008; Lindberg, 1992; Woods, 2005). From a practical point of view, it appears to an observer that the Earth is stationary and the heavens are revolving. From an astronomical point of view, stellar parallax had not been observed and would not be observed until telescopes were sufficiently improved in strength and clarity. Stellar parallax is observed as a result of the different orbital positions of the Earth, which causes nearby stars to appear to move relative to more distant stars. The angle of stellar parallax is so minute because of the distances of the stars that its detection was simply impossible until the mid-19th century. Stellar parallax was at last observed in 1838 by the German mathematician and astronomer, Friedrich Bessel, which finally confirmed the heliocentric model three centuries after Copernicus proposed his theory and two centuries after Galileo's death (Hess & Allen, 2008).

Early Protestant Objections to Copernicanism

In 1539, a Lutheran scholar from the University of Wittenberg, Georg Joachim Rheticus (1514-1574), resigned his chair of mathematics and traveled to Frombork to study under Nicholaus Copernicus (Hess & Allen, 2008). Rheticus had met Copernicus 39 years before, in 1500, and they had discussed his heliocentric theory. But their association began seventeen years before the onset of Protestant Reformation in Germany and open discourse among Catholic and Protestant scholars had since ceased (Hagen, 1908). In fact, Rheticus was compelled to resign his position at the Lutheran university in order to study under Copernicus. He became Copernicus's first disciple and in 1540 he published his own sketch of the heliocentric system, entitled *Narratio Prima.* At 68 years of age Copernicus was nearing the end of his life and finally wrote to Pope Paul III informing him that he would yield to the repeated requests of Cardinal Schonberg and the Bishop Giese of Culm and hand over his manuscripts for publication (Hess & Allen, 2008).

Bishop Giese discerned that Rheticus was Copernicus's ablest supporter and charged him with editing the manuscript for publication, which he did (Hagen, 1908). Rheticus hoped to bring the manuscript to Wittenberg for publication at the university, but the open opposition at the Lutheran university against the Copernican system was such that only the chapter on trigonometry could be published in 1542. The Vatican Library currently holds to copies of the original 1542 publication. Rheticus wished to resume his chair at Wittenberg, but was forbidden by the Lutheran school because of his open endorsement of the Copernican model. Not only had he publicly supported the Copernican theory, he had also anonymously published a narrative in which he defended Copernican's cosmology from scripture. Rheticus addressed the Scriptural passages that seem to refer to the stability of the Earth by reiterating St. Augustine's figurative interpretive method, which had been denounced by Martin Luther and his principal disciple, Melanchthon (Hagen, 1908).

Due to opposition to heliocentrism at the University of Wittenberg, Rheticus turned to his scientific friend Schoner, in Nuremberg and the Lutheran theologian and Reformer, Andreas Osiander, for their assistance in publication (Hagen, 1912; Hess & Allen, 2008). Osiander was uniquely aware of the strenuous objections that had been voiced by the leading Protestant Reformers toward the heliocentric model, as well as the open hostility that existed at Wittenberg. Dreading the anticipated backlash in Protestant circles, Osiander took it upon himself to attempt to allay the effect of the imminent publication (Hess & Allen, 2008; Stark, 2003; Wiker, 2011; Woods, 2005).

Prior to publication of *De revolutionibus orbium coelestium libri sex* (i.e., *Six Books on the Revolutions of the Celestial Orbits*) by the Johannes Petreius publishing house in Nuremberg, Osiander took it upon himself to inserted the word “Hypothesis” on the title-page (Hagen, 1908; Hess & Allen; Wiker, 2011). Next, without adding his own name, he wrote his own preface in place of Copernicus's preface. Osiander's preface stated, "[t]hese hypotheses need not be true nor even probable; if they provide a calculus consistent with the observations, that alone is sufficient…" (as cited in Hess & Allen, 2008, p. 35). The simplicity and elegance of the heliocentric system was sufficient to convince a genius like Copernicus and he never referred to his system as a hypothesis (Hagen, 1908; Hess & Allen, 2008; Wiker, 2011). Osiander had taken it upon himself to present Copernicus's heliocentric model to the world in a manner that he judged would be acceptable to Protestant sensibilities – as a hypothesis (Hess & Allen, 2008; Wiker, 2011; Woods, 2005).

Copernicus, who had suffered a stroke and memory loss in the interim, never knew of the changes to his intent (Hagen, 1908;Wiker, 2011). Osiander's reservations were well founded in light of the severe opposition to the Copernican system that had been voiced by the leading Protestant Reformers (Hess & Allen, 2008; Wiker, 2011). The Reformers had supplanted the traditional Christian exegetical interpretive tradition that had been reiterated through the centuries by such figures as Origen, St. Augustine, Isadore of Seville, St. Martin of Tours, Alcuin, John Scotus Eriugena, Abelard, St. Thomas Aquinas, and several others, for a fervent insistence on a literal interpretation of Scripture (Stark, 2003; Woods, 2005).

For example, Martin Luther, reacted in his characteristically overbearing manner, referring to Copernicus as "a fool who went against Holy Writ" (as cited in Pogge, 2005, para. 3). Even four years prior to the publication of the Copernican system, Luther marveled at the "indignation at the impiety of those who admitted the hypothesis of solar rest" (Duhem, 1911, para. 44). Luther warned his disciples:

> There is talk of a new astrologer who wants to prove that the earth moves and goes around instead of the sky, the sun, the moon, just as if somebody were moving in a carriage or ship might hold that he was sitting still and at rest while the earth and the trees walked and moved. But that is how things are nowadays: when a man wishes to be clever he must needs invent something special, and the way he does it must needs be the best! The fool wants to turn the whole art of astronomy upside-down. However, as Holy Scripture tells us, so did Joshua bid the sun to stand still and not the earth (as cited in Pogge, 2005, para. 2).

Luther's most important disciple, Philip Melanchthon, acknowledged the mathematical and astronomical accuracy of the Copernican system, but still fervently opposed the hypothesis that the Earth moves (Duhem, 1911). In formulating his argument against the Copernican system, in addition to arguments informed by a literal interpretation of scripture, Melanchthon resorted to arguments from Aristotle's peripatetic physics, which scholars had by then systematically discredited. Melanchthon referred to Copernicus's work as, "love of novelty" and added, "it is part of a good mind to accept the truth as revealed by God and to acquiescence in it" (as cited in Wiker, 2011, p. 42). In 1549, he again referred to Copernicus in his publication *Initia doctrinae physicae* (i.e., *Elements of the Knowledge of Natural Science*), writing: "The joke is not new... The young should know it is not decent to defend such absurd positions publicly" (as cited in Ferngren, 2002, p. 99). Melanchthon's son-in-law, Kaspar Peucer, took his turn and discounted the Copernican system as absurd (Duhem, 1911).

Similarly, as a result of his literal reading of scripture, the Protestant Reformer John Calvin also attempted to discredit the Copernican system (Osborn, 2010). Calvin cited the 93rd Psalm, "the world is established; it shall never be moved," and asked: "Who will venture to place the authority of Copernicus above that of the Holy Spirit" (as cited in Wiker, 2011, p. 42). Calvin delivered an exegesis of the 93rd Psalm in a sermon, which expressed the reasons for his opposition to the Copernican model:

> The heavens revolve daily, and, immense as is their fabric, and inconceivable the rapidity of their revolutions, we experience no concussion. ... By what means could it [the earth] maintain itself unmoved, while the heavens above are in constant rapid motion, did not its Divine Maker fix and establish it? (Dowd, n.d., para. 36).

The Lutheran University of Wittenberg studied Copernicus's work after the publication of *De revolutionibus* and appreciated the mathematical aspects of the work, but Gingerich (2000) noted they patently ignored the heliocentric aspects. Both students and professors at Wittenberg limited their analysis to aspects of trigonometry. Historian Robert Westman labeled their deliberate evasion of the cosmological aspects of Copernicanism as, "the Wittenberg interpretation" (Ferngren, 2002, p. 98).

Features of Copernican's Model

Ptolemy, and Aristotle before him, had theorized that the heavenly bodies revolve in perfect circular motion at uniform speed (Hess & Allen, 2008; Jaki, 1990; Lindberg, 1992). However, prediction of the positions of the planets and the risings and settings of stars could not be accomplished using perfect circular motions alone, so to preserve the assumption of uniform circular motion, Ptolemy employed epicycles and eccentrics to account for the inconsistencies. Copernicus sought to more elegantly and accurately calculate the length of the solar year and determine risings and settings, but because he too assumed perfect circular motions of the heavenly bodies and uniform speeds, he too was compelled to use epicycles in his heliocentric model. The result was that the Copernican model was mathematically extraordinarily complex and only slightly more accurate than the long-accepted Ptolemaic model (Wiker, 2011). The slight improvement of the predictive accuracy of the Copernican model over the Ptolemaic model was simply not enough to convince the scholarly community to replace the long-accepted Ptolemaic system. More work remained to be done before the majority of astronomers would concede the superiority of the Copernican model (Woods, 2005).

Copernicus's system did, however, make logical sense out of the order of the planetary bodies and provided an intrinsic order not found in the Ptolemaic system (Lindberg, 1992). Also, the Copernican model offered a logical explanation for retrograde motion. Rather than interpreting the looping paths of the planets against the sidereal backdrop as being actual celestial occurrences, Copernicus understood retrograde motion as mere optical illusions. That is, optical illusions that result from the annual revolution of observation points from earth, inside or outside the orbits of the other planets (Hess & Allen, 2008). Heliocentrism still required additional fine-tuning before its accuracy could be confirmed and more powerful astronomical instruments had to be developed before it could be conclusively proven.

Within 50 years of Copernicus's death, Lutheran astronomer Tycho Brahe (1546–1601) proposed an alternative to Copernican's system (Hess & Allen, 2008). He proposed a geo-heliocentric model, wherein the five planets revolve around the sun, which in turn revolves with the moon around the Earth. Dreyer (2004) explained that Brahe appreciated Copernicus's success in circumventing the most problematic aspects of the Ptolemaic system, but could not ascribe to the "sluggish earth" the swift motion shared by the "ethereal torches" (as cited in Hess & Allen, 2008, p. 37). Tycho Brahe's brilliant successor, Johannes Kepler, along with Sir Isaac Newton, would complete the heliocentric model over the course of the next two centuries with their respective contributions of elliptical orbits and law of universal gravitation (Hess & Allen, 2008).

Brahe did, however, successfully overcome two additional Aristotelian notions concerning the heavens (Hess & Allen, 2008). The first was Aristotle's dictum that the heavens are immutable, which Brahe controverted after observing a nova in 1572, which he perceived was a *stella nova* or new star because it exhibited no parallax – no progressive displacement against the background of the "fixed stars." After observing a comet in 1577 which undeniably looped around the sun, Brahe negated a second Aristotelian idea that claimed the crystalline spheres are fixed and solid.

Although the intellectual climate of the late Middle Ages fostered copious creative thought, including astronomical speculations, the ecclesio–political climate following the Protestant Reformation dramatically altered the situation (Hess & Allen, 2008). Science had progressed through the course of centuries, essentially unencumbered within Catholic Europe, but by now, Protestantism – with its literal reading of scripture – had spread to almost half of Europe. As a result, in the years between Copernicus and Galileo Galilei, the heliocentric theory was continually debated and analyzed within Catholic universities across Europe, but in Protestant controlled regions and universities the Copernican system was official renounced. Nonetheless, the work continued within the Catholic universities to either confirm or refute the Copernican model and Jesuit astronomers and mathematicians were at the forefront of those scientific efforts (Wiker, 2011; Woods, 2005).

Christopher Clavius (1538–1612)

Christopher Clavius is an essential figure in both the history of science and history of Christian Europe, in that his scientific achievements are directly linked to his religious faith and his acceptance of the long-accepted Christian understanding of an intelligible universe. Clavius was a Bavarian born Jesuit priest and distinguished mathematician and astronomer of the Roman College (Woods, 2005). He was greatly respected by both Catholic and Protestant scholars of his day, including Tycho Brahe, Johann Kepler, Galileo Galilei, and Giovanni Antonio Magini. His mathematical expertise was such that even during his lifetime he was known as the "Euclid of the sixteenth century" (as cited in Muller, 1908, para. 1).

Clavius's copious writings reflect his interest and expertise in a wide range of scientific disciplines (Muller, 1908). His genius is possibly best exemplified in the collection of five large volumes he authored entitled, *Christophori Clavii e Scoietate Jesu* *opera mathematica, quinque tomis distributa*, which contained discourses on Euclidian geometry; practical geometry; algebra; a dissertation on the astrolabe; the most exacting discussion of gnomonics (i.e., the art of construction of all potential sun-dials) up to that time; and the fifth volume is a comprehensive analysis of the Gregorian Calendar of 1582 for which he is most well-known (Muller, 1908).

Hess & Allen (2008) noted that in the years between Copernicus and Galileo, the papacy gave extravagant sums of money in support of the study of astronomy. For example, Pope Gregory XII (1502–1585) erected a tower within the Vatican for the purpose of establishing would become the Vatican Observatory and also ensured that it was equipped with the latest astronomical implements. The first project undertaken at the Vatican Observatory was calendar reform, due to the inaccuracies of the Julian calendar which had magnified over time. By the 16th century the Julian calendar was out of phase four days in relation to the lunar calendar. Lattis (1994) recorded that Pope Gregory assembled a committee of experts to study the scientific data involved in calendar reform and because of his mathematical and astronomical abilities, Clavius was the committee's foremost expert (as cited in Hess & Allen, 2008). By 1582, the Gregorian calendar had been developed and implemented throughout the Catholic world (Woods, 2005).

Modern astronomers marvel at the accuracy and precision of the Gregorian calendar (Hess & Allen, 2008). Clavius calculated the precise length of the solar year and the number of days necessary to keep the calendar in accord with the solar year, which entails 97 leap days every 400 years (Woods, 2005). More specifically, an intercalary or leap day was added to the calendar every four years, which occurs on

February 28, but there is no leap year in years ending with "00", unless those years are divisible by 400. So, for example:

> …the years 1700, 1800, 1900, and 2100 would not be a leap year but the years 1600 and 2000 would. This change was so accurate that today, scientists need only add leap seconds every few years to the clock in order to keep the calendar matching the tropical year (Rosenberg, 2013, para. 6).

The socio–political and religious climate present in Europe following the Protestant Reformation is exemplified by the Protestant reaction to Pope Gregory's calendar reform (Ferngren, 2002). Irrespective of its accuracy and advantages, Protestant nations refused to adopt the Gregorian calendar – some for several centuries – on the grounds that it was "popish" (i.e., promulgated by the pope). Protestant regions of Germany did not adopt the new calendar until 1704 and Protestant England and their American colony did not adopt the new calendar until 1751, after the Julian calendar had slipped a full 13 days (Wilde, 2013).

Christopher Clavius is representative of the mathematical/astronomical tradition which dates back in Christian Europe since at least the time of Gerbert (i.e., Pope Sylvester II) at the close of the first millennia (Ferngren, 2002; Hannam, 2011; Lindberg, 1992; Walsh, 1915; Woods, 2005). Clavius is famous for his continuing discourse with Galileo, who possessed great admiration for the Clavius and his expertise. Still, his most important contribution to science remains the calendar reform of 1582 that was enacted by Pope Gregory XII and is still in use worldwide (Hess & Allen, 2008).

Clavius and the Mathematics Curriculum

Clavius is eminently important within the context of mathematics and science, but also in the context of mathematical pedagogy (Gatto, 2006). He published an important commentary on *Euclid's Elements* and his 1574 work, *Ordo Servundum in Addiscendis Disciplinis Mathematicis* is considered a milestone in mathematical pedagogy. He also produced the *Ordo Servundum in Addiscendis Disciplinis Mathematicis*, as a syllabus for mathematical studies within Jesuit colleges that was intended to be used in training mathematics teachers. The work is considered a masterpiece of pedagogic technique, as it was presented in an innovative modular format for purposes of clarity. The work was quickly implemented worldwide within Jesuit secondary schools, colleges, and other Church sponsored institutions of higher learning. Although mathematics had always been taught in the Church sponsored schools, including the European university system, Clavius was instrumental in convincing the Church hierarchy and administrators of education of the value in emphasizing mathematics as a discipline of its own – apart from the other sciences (Gatto, 2006).

The importance of Clavius's endorsement of the idea to broaden the curriculum to emphasize mathematics in a more profound way can hardly be overstated and the various scientific disciplines profoundly benefited as a result of his insight (Lindberg, 1992; Wiker, 2011; Woods, 2005). Mathematics plays a vital role in virtually every scientific discipline and their associated discoveries. Instructing future scientists in mathematics, prior to and during their specialization, is an essential Jesuit pedagogical innovation that is still implemented in 2014 and one which Clavius dedicated his life's work to achieving

(Gatto, 2006). However, conflict theorists persistently take note of historical incidences and figures that cannot be viewed in such a positive light. Thus, in keeping with the norms of rigorous historical research, which requires transparency through analysis of both confirming and disconfirming cases (Haider, 2011), the following section describes the most commonly cited historical instances of Christianity's alleged resistance to science.

Alleged Resistance to Science by the Church

The case of the Dominican friar, Giordano Bruno (1548-1600), is frequently cited by those who advance the notion that faith and science are discordant or incompatible human endeavors (Draper, 1874; Hess & Allen, 2008; Hannam, 2011; Jaki, 1990; Walsh, 1915; White, 1896). Bruno's case is cited as a precursor to the Galileo affair and proof of an ongoing war between religion and science. It is true that prior to his excommunication by both the Calvinists and Lutherans and his later rejection by the Anglicans, Bruno had charges of heresy brought against him by the Catholic Church. But Bruno was not condemned by the Inquisition because of his view on science, his so-called defense of Copernicanism, or his assertion of a plurality of inhabited worlds. He was condemned by four different Christian denominations, in a variety of nations, because of his pantheistic theological teachings, which he made public under the pretext of teaching science (Hannam, 2011).

Publically promoting theological ideas deemed heretical during the Middle Ages was viewed as a form of insurrection and an intentional undermining of society, but not simply because the Church hierarchy viewed heresy as such (Hannam, 2011). Heresy was viewed in the same way by the governments of Europe, which at the time all professed the Christian faith. Thus, in the thoroughly Christian milieu that has been termed Christendom, a public profession of beliefs deemed contrary to Christianity was viewed with grave suspicion (Smith, 1912).

Since the first-century debates between the early Church Fathers and pagans of Greece and Rome, the Catholic Church had no tolerance for pantheistic speculations (Lindberg, 1992). Nonetheless, following his rejection by Catholics in Italy for airing his pantheistic beliefs under the guise of teaching science, Bruno traveled to the Calvinists in Geneva, then to the Lutherans in Germany, and then to the Anglicans at Oxford. In each case, he was censored and rejected for his pantheistic teachings (Turner, 1908). For example, he proposed that the earth rotates around the sun, so that its soul can benefit from the seasons and then scolded his audience for being backward looking when some questioned his reasoning. During another Oxford lecture a student realized Bruno was plagiarizing another author's work and brought a copy of the book to Bruno's next lecture. After having been exposed as a plagiarist and publically humiliated, Bruno returned to the European mainland, where he traveled around for almost ten years, voicing his beliefs to anyone willing to listen (Hannam, 2011).

In 1591, Bruno left Oxford for Venice and traveled to the aristocratic Giovanni Mocenigo, who was interested to learn Bruno's self-professed, secret system of memory training (Hannam, 2011). But after failing to discern Bruno's magical secret, Mocenigo turned him over to the Inquisition as a heretic and he was abruptly arrested by the Venice authorities. The Roman Inquisition intervened and requested that Bruno be transferred to

Rome for trial. While awaiting trial, Bruno's problems mounted when he openly discussed his ideas with a fellow prisoner. The Inquisition then procured copies of all of his books, which contained 600 pages of evidence.

Nine years later, in 1599, the Inquisition finally put Bruno on trial for heresy (Hannam, 2011). His file was given to the Jesuit Cardinal, Robert Bellarmine, who later tried Galileo. Bellarmine listed eight heretical statements no one could deny Bruno had made. His statements reiterated such ancient pagan and pantheistic beliefs and directly opposed Christian doctrine: (a) the universe and earth possess eternal souls; (b) the universe is eternal, and thus, was not created by God); (c) no reality or matter exists that does not possess a spirit and intelligence; (d) the stars act as messengers and interpreters of the ways of God (MacLachlan, n.d.); (e) Christ was not God, but was merely an unusually skilled magician; (f) the Holy Spirit is the soul of creation; (g) in the end the Devil will be saved; (h) God and the world are one (i.e., matter and spirit and body and soul are two phases of the same substance) (Turner, 1908). Confronted with the evidence against him, Bruno agreed to recant his statements and due penance, which according to the Inquisition was to be his only sentence.

Strangely, Bruno then undermined the process by writing a letter to the pope, wherein he declared his eight statements were not heretical at all (Hannam, 2011). The Inquisition lost any patience they had exercised up to that point and gave Bruno forty days to repent or face the stake. With incredible bravery or insanity, Bruno refused to repent and was handed over to the secular government in Rome, who in turn burned him at the stake on February 17, 1600. In short, Bruno's condemnation had nothing to do with science (Turner, 1908), but was actually the direct result of his promotion of pantheistic notions that were understood to be a form of civil insurrection and which were also, specifically opposed to science (Jaki, 1990; Woods, 2005).

It is true that Bruno had admired Copernicus's heliocentric theory, but the scholarly consensus is that he lacked the necessary training in mathematics necessary to comprehend the complex mathematical calculations that comprise Copernicanism (Hannam, 2011). Moreover, Bruno actually criticized Copernicus's fascination with mathematics and rejected the central tenant of Copernicanism, which is the idea that an observable and cogent mathematical representation of the universe can be formulated (Jaki, 1990). Bruno simply used aspects of Copernicanism in a utilitarian way – only when Copernicanism benefited his pantheistic theology. His was a tragic case indeed, but not an illustration of a conflict between religion and science. The case of Giordano Bruno is a case of religious intolerance of competing religious beliefs in a post-Protestant Reformation climate (Jaki, 1990).

Conflict theorists also commonly cite the 16th century Platonic philosopher, Francesco Patrizi (1529–1597), as an example of the Church's deep seated antagonism toward heliocentrism (Hannam, 2011). Patrizi published a work that included three principal hypotheses: (1) the Earth rotates for similar reasons previously outlined by Oresme; (2) vacuums may exist in nature; and (3) a mystical Platonism should replace Aristotelian materialism. The Church's censorship office reviewed the work and subsequently ordered Patrizi to amend his work, but the ecclesial authorities voiced no objections to Patrizi's assertions concerning the Earth's rotation, the existence of vacuums in nature, or any portion of his work germane to physics. He was ordered to revise his mystical Platonic philosophical speculations, which were deemed inconsistent with Catholic theology (Brickman, 1941). Subsequent to the completion of the philosophical revisions, the pope himself affirmed that Patrizi was to retain his professorship of Platonic philosophy. It is probable that Galileo was influenced by Patrizi's speculations concerning the Earth's rotation, as well as the possible existence of vacuums in nature, but Patrizi's Platonic mysticism does not seem to have impressed Galileo (Hannam, 2011).

Notwithstanding some of the confused philosophical speculations of the time, which were proffered under the guise of teaching science, the 16th century did produce another brilliant mathematician and astronomer, who made his own unique contributions to the heliocentric model.

Johan Kepler Advanced Heliocentrism

Chapter 1 herein, noted how two books published in the late nineteen-century fundamentally framed the debate concerning the historical relationship of faith and science (Ecklund & Park, 2009). In his 1874 book, *History of the Conflict between Religion and Science*, John Draper advanced the notion that the oppressive Catholic Church actively sought to obstruct scientific advancement. In 1896, Draper's friend and cofounder of Cornell University, Andrew Dickson White, published *A History of the Warfare of Science with Theology in Christendom*. Those two books forcefully argued that faith and science are mutually exclusive human enterprises and conflict theorists continue to advance various forms of that thesis (Dawkins, 2006; Harris, 2004; Knight & Lomas, 200).

The presentist conflict thesis consists of various elements (Wilson, 2002) that have been repeated so often that they are now seemingly embedded in Western culture (Russell, 2002). One pillar of the conflict thesis is the charge that the development of empirical science within Catholic Europe was a mere coincidence, and in fact, science would have advanced much more rapidly if it were not for continual interference by the Church of Rome (Stark, 2003). An alternate, but similar version of the conflict thesis purports that science was unable to flourish until freed from the influence of the Catholic Church by the Protestant Reformation (Knight & Lomas, 2001). As noted above, the history surrounding the development and eventual acceptance of the heliocentric model speaks directly to these elements of the conflict theory and the circumstances of Johannes Kepler's life and career were an integral part of that history.

Johannes Kepler was born in 1571 near Stuttgart, Germany (Hannam, 2011). He attended the University of Tubingen, where he originally intended to become a Lutheran minister, but was soon motivated to dedicate himself to mathematics and astronomy. Above all, in keeping with the Christian worldview, Kepler believed that God is the author of creation. His faith led him to the conviction that the heavens must reflect the elegance and perfection of God. Kepler set out to prove that the perfection of the cosmos could be revealed through the exactness of geometry. In fact, his most important contribution to the heliocentric model – elliptical planetary orbits – was eventually achieved after he completed exhausting calculations that led him to abandon Aristotle's notion of perfectly circular orbits and settle on elliptical planetary orbits, which he also considered as an elegant arrangement (Jaki, 1990). "For a long time, I wanted to be a theologian," he penned, "now however, behold how through my effort God is being celebrated through astronomy" (Hannam, 2011, p. 295).

Kepler's astronomy professor at the University of Tubingen was Michael Maestlin (Hannam, 2011), who for many years maintained regular correspondence with the renowned astronomers Tycho Brahe and Christopher Clavius. Thus, he was able to relate the latest astronomical theories and developments to his students, including Kepler. Gingerich (2000) observed that Maestlin is most famous for his virulent criticism of the "popish" Gregorian calendar that Clavius had so meticulously designed, and significantly, Maestlin was ambiguous about the Copernican model (as cited in Ferngren, 2002, p. 100). Still, Maestlin was a key figure in science simply because he first introduced Kepler to Copernicus's theory. Kepler became so captivated by the Copernican model that he abruptly halted his theological studies and completely dedicated himself to the study of astronomy and mathematics (Ferngren, 2002).

With Maestlin's assistance, Kepler published his first book in 1596, entitled *Mysterium cosmographicum* (i.e., *Cosmographic Mystery*), but the climate following the Protestant Reformation was such that Kepler's work was abruptly suppressed by the Lutheran university senate. Kepler had included a scriptural defense of the Copernican model, wherein he interpreted some Old Testament passages allegorically, which was in keeping with the Catholic tradition, but discounted by Protestants. Protestants rejected his work because they held to a literal interpretation of scripture (Ferngren, 2002).

During the course of his career, Kepler was unable to find a reliable Protestant benefactor to support his work because although his religious beliefs were Protestant, they did not harmonize with any particular denomination (Hannam, 2011). So, for example, the Lutheran pastor at Lynz, Austria told Kepler to recant his heterodox views toward Lutheranism and when he refused, he was denied communion and left the region (Ferguson, 2002). On another occasion, he was rejected by the Lutheran Duke Johann Friedrich of Wuerttemberg, because he was suspected of being “a sly Calvinist” (as cited in, Kepler, 1995, Patronage section, para. 3). To further his difficulties, the Calvinists accused his mother of witchcraft and Kepler spent several years trying to free her. "It makes me heartsick," he lamented, "that the three big factions have so miserably torn up the truth among themselves that I have to gather the little scraps together wherever I find them" (Ferguson, 2002, p. 330).

Unwelcome in Protestant regions, the vast majority of his career was spent under the patronage of Catholic royalty, who overlooked his religious convictions because of his genius (Hannam, 2011). Indeed, for a time, Kepler was sheltered by the Church precisely because of his acceptance of heliocentrism and “…was allowed as a Protestant to stay in Catholic Graz as a Professor (1595-1600) when other Protestants had been expelled” (as cited in Johannes Kepler, 2013, para. 2). Kepler simply saved his theological defense of the Copernican model that the Lutheran university senate had previously rejected and inserted it into his last book, *Astronomia nova* (i.e., *New Astronomy*). In 1609 he dedicated *Astronomia* to his long-time Catholic patron, the Holy Roman Emperor, Rudolph II, of the House of Habsburg. He dedicated several books, prepared numerous scientific reports, and served in the imperial court, until the emperor's death (Kepler, 1995).

In 1597, the most famous astronomer in the world was the Lutheran, Tycho Brahe (Wiker, 2011). Following a dispute between Tycho and his Protestant benefactors in Denmark, Rudolph II successfully enticed Tycho to join his court. Kepler had suffered a childhood illness that affected his vision, which made successful astronomical observation impossible, so Kepler's talents were limited to calculation and theorizing (Hannam, 2011). In order to accurately ascertain whether or not the Copernican model reflected nature, he desperately needed accurate astronomical data. Over the course of several decades, Tycho Brahe had painstakingly amassed the most impressive collection of astronomical data available. Tycho, however, was adamantly against sharing his astronomical charts and tables with anyone. Notwithstanding Tycho's objections, Rudolph II brought Kepler to his court to serve as Tycho's assistant. Their task was to organize all of the astronomical data and prepare it for publication, as the *Rudolphine Planetary Tables* (p. 294).

Their working relationship was strained to the point that Kepler said he felt like Tycho's "housedog" (Simon Fraser University, n.d., para. 1). Within six months, Tycho was on his deathbed and handed over his astronomical data to his assistant for publication (Hannam, 2011). Shortly thereafter, Rudolph II promoted Kepler by appointing him to the position of imperial mathematician and from that point forward, Kepler had continual access to Tycho's observational charts (p. 295).

Kepler's Model

Kepler pored over Tycho's accumulated data and focused his attention on the orbit of Mars (Hannam, 2011). He determined that Tycho's most precise analysis, which included Ptolemy's eccentrics and epicycles, was off by eight minutes of arc or 2/15 of a degree. Tycho’s diagrams indicated the position of Mars at a particular moment in time and Kepler compared the charted position to reality. The difference in the position of Mars in its orbit, at a particular moment in time, was off approximately the width of a pencil line (Simon Fraser University, n.d.). The accuracy of Tycho’s data is even more astonishing when one considers that he performed all of his observations without the benefit of a telescope, which had not been invented yet. Kepler’s Christian understanding was that God is simply not capable of making an eight-minute error, but rather, God’s handiwork is consistent, elegant, and intelligible (Hannam, 2011; Jaki, 1990; Jaki, 2000; Woods, 2005). Kepler focused on the discrepancy between Tycho's data and the actual position of Mars in the sky and correctly discerned that the orbit of Mars is not circular, but an ellipse (Ferngren, 2002; Hannam, 2011; Hess & Allen, 2008; Jaki, 1990; Lindberg, 1992; Walsh, 1915; White, 1896; Stark, 2003; Woods, 2005).

Copernicus had earlier taken a monumental step forward toward heliocentrism, but never deviated from circular planetary orbits, so never achieved empirical accuracy (Hannam, 2011). Kepler discovered elliptical orbits by pouring over Tycho Brah’s life’s work. Concerning his Christian worldview and Tycho’s data, Hannam (2011) remarked that Kepler "…completed the chain between religion and science" and "his ideas about God provided his hypothesis, he had the mathematical ability to turn his ideas into a system, and, at last, Tycho's data meant he could check to see if his system was actually true" (p. 296).

Kepler's discoveries didn't stop with elliptical orbits (Hannam, 2011). He confirmed Copernicus's calculations that had shown a planet's uniform motion was not its absolute speed. Kepler also observed that the planets move faster when they are closer to the sun and slower as they move further away. Moreover, Kepler discovered that the axis of a planet's orbit swept through an equal area in any given time, which was the uniformity that he had searched for. Kepler later discovered the mathematical relationship between a planet's distance from the sun and the length of time it takes to orbit the sun (Hannam, 2011).

The first two of Kepler's "Three Laws" in support of the heliocentric model were published in 1609 and the third in 1619. They are usually stated in the following terms (as cited in Stern, 2005, para. 5):

1. Planets move around the Sun in ellipses, with the Sun at one focus
2. The line connecting the Sun to a planet sweeps equal areas in equal times.
3. The square of the orbital period of a planet is proportional to the cube (3rd power) of the mean distance from the Sun.

Unfortunately, although Kepler was a brilliant mathematician and astronomer, writing was not among his talents (Hannam, 2011). Although he produced volumes of work, his style rendered them practically unreadable. His work and discoveries are complex in and of themselves, but his mystical thought processes that he incessantly interjected, expressed in page after page of notes, made them even more convoluted. The nature of Kepler's published material was such that his discoveries were largely overlooked for another hundred years. Galileo was given a copy of Kepler's work in which he proposed elliptical orbits, but Galileo never made use of elliptical orbits or the extraordinary accurate *Rudulphine Tables* in his own work. Galileo did, however, write to Kepler acknowledging his work, and received a return letter from Kepler and additional copies of his book. Given his self-centered character, Galileo may have ignored Kepler's work out of professional jealousy or it may simply have been a result of Kepler's obscure style of writing (Hannam, 2011).

The astronomical tables were finally published in 1627, which combined Tycho's thorough observation and cataloging with Kepler's elliptical theory of planetary motion (Hannam, 2011). The accuracy of the tables was such that they quickly became the standard throughout Europe and the tables also accounted for the widespread acceptance of Kepler's laws. Astronomers had been trying to accurately predict planetary positions for several millennia. Ptolemy's geocentric system was very accurate and had been the standard for more than 1000 years. Copernicus's heliocentric system was only slightly more accurate than Ptolemy's because, like Ptolemy, he proposed circular planetary orbits. Kepler's elliptical orbits completed the process by enabling near-perfect prediction of planetary positions. Although heliocentrism was not substantiated until the mid-19th century when stellar parallax was finally observed, practically speaking, astronomers knew the truth of heliocentrism after studying Kepler's astronomical tables (Hannam, 2011; Jaki, 1990; Lindberg, 1992; Stark, 2003

Kepler's scientific contributions were extremely significant, but his understanding of the Christian faith led him into some peculiar errors (Jaki, 1990). For example, in one instance he let his Protestant theological presuppositions taint his empirical investigation of nature when he attempted to calculate the exact date of creation. It is ironic that even in light of the fact that he had previously proposed a figurative interpretation of some Old Testament passages in arguing for heliocentrism, he still believed that the time since the moment of creation only amounted to a few thousand years of Biblical chronology. Thus, the great scientist took the time to meticulously calculate "…the date of creation at 3977 B.C., April 27, Sunday, at 11:00 a.m., Prussian local time" (as cited in Jaki, 1990, p. 269). Twenty-five years later, in his publication *Epitome astronomiae copernicanae*, he claimed to have concluded through wholly astronomical reckoning, "that it is impossible that the world should not have been created at a fixed beginning in time" (as cited in Jaki, 1990, p. 269), although the specifics of his argument were not convincing.

Notwithstanding the significance of Kepler's contributions to astronomy and physics, his contemporary and fellow astronomer, Galileo, garnered more fame and notice during their lifetime and beyond. The controversies surrounding Galileo have eclipsed his own scientific achievements and morphed into what have become some of the most deeply imbedded myths in the history of science (Pernoud, 1977/2000), which now permeate science curriculum content (Boorstin, 1983). Galileo made some very significant contributions to physics and astronomy, but unfortunately, the religious climate following the Protestant Reformation (Stark, 2003), combined with unhelpful aspects of his personality, detracted from his ability to accomplish his principle objective, which was the promotion of the heliocentric model (Woods, 2005).

Galileo Galilei (1564 –1642)

Chapter 1 above noted some of the more well well-known myths related to science and science curriculum content and the Galileo affair almost certainly accounts for more recurrent myths associated with the history of science and science curriculum, than any other single event in the history of science (Woods, 2005). Some of the recurring myths pertaining to Galileo are: (1) that he was tried for discovering or proposing that the Earth revolves around the sun; (2) that he was threatened with torture; (3) that he was tortured; (4) that he wallowed in a dungeon after being sentenced (D'Souza, 2008; Harris, 2004; Smollett et al., 1905; (5) that he was sentenced to death; (6) that he was blinded by his imprisoners (Gerard, 1909); (7) that Church authorities refused to listen to the evidence he presented in defense of Copernicanism; (8) that the Church refused him burial on consecrated ground; and (9) other myths that involve exaggerating his importance to science in general (Hannam, 2011; Wiker, 2011). The historical reality concerning Galileo is considerable more interesting that the legends surrounding his life and work. Galileo did more to popularize the Copernican model than any other single individual in history and although he was unable to prove the truth of heliocentrism, his discoveries provided more evidence for its validity (Hess & Allen, 2008).

The central research question herein, enquires as to facts and insights that may be learned concerning the historical relationship of faith and science that can be of use to educators, as they confront present challenges related to science curriculum content. Moreover, the first subquestion herein concerns what significance can be attributed to faith, if any, to the development of science in the period between the fall of the Roman Empire through the Renaissance. Additionally, chapter 1 above noted several of the most prominent myths surrounding the history of science in general and Galileo, in particular, which repeatedly surface in science curriculum content. Thus, the events surrounding what has come to be known as 'the Galileo affair,' which one scholar described as an "archetype" of the conflict theory (Becker, 2009), are relevant to this study.

Notwithstanding Galileo's important contributions to physics and astronomy, largely on account of his now famous conflict with Church authorities, he has become a tool used by and favorite of conflict theorists (Stark, 2003). As a result, Galileo's discoveries, accomplishments, and importance to science, have been inflated, while the specifics of his conflict with Church authorities have been distorted (Hannam, 2011; Wiker, 2011). One contemporary example will attest to the extent to which Galileo's accomplishments and importance to science have been inflated. In 1998, the much celebrated theoretical physicist, Stephen Hawking, wrote:

> Galileo's renowned conflict with the Catholic Church was central to his philosophy. He was one of the first to argue that human beings could hope to understand how the world works, and, moreover, that we could do this by observing the real world. Galileo, perhaps more than any other single person, was responsible for the birth of modern science (as cited in Wiker, 2011, p. 36).

Galileo Galilei is arguably the most famous scientific figures of the last thousand years and his case has probably been analyzed, discussed, and debated more than any other scientific figure in history (Principe, 2011). But without question, he was not one of the first to argue that human beings could hope to understand how the world works by observing the real world. Nor was he responsible for the birth of modern science (Wiker, 2011). Nonetheless, traditional histories of science portray Galileo as a man of unparalleled originality and innovation (Hannam, 2011). He has been portrayed as the first person in history to demonstrate that objects of different weights fall at the same speed and the first to contend that vacuums can exist in the natural world. It is also claimed that he was the first to assert that projectiles fall in a curved trajectory and that he set a new path by rejecting Aristotle when everyone else accepted his dictums unqualifiedly. Traditional histories of science also convey that Galileo proved Copernicus to be correct, and as a result, the Inquisition tried him and cast him into prison (p. 303). He is also regularly credited with having invented the telescope (Clerke, 1907). Unfortunately, none of these assertions concerning Galileo's achievements are entirely accurate (Hannam, 2011; Hess & Allen, 2008; Jaki, 1990).

Galileo was certainly a remarkable scientist and made momentous discoveries in science (Hannam, 2011; Jaki, 1990; Lindberg, 1992). But like his predecessors and successors in science, Galileo’s notable contributions to should be recognized as part of the steady advancement of science that had begun centuries earlier (Jaki, 1990; Stark, 2003; Wiker, 2011; Woods, 2005). In truth, Galileo’s genius largely rests in his ability to formulate a coherent hypothesis based on the theories and principles that had already been developed by his predecessors (Hannam, 2011; Hess & Allen, 2008).

Galileo's Early Career

Galileo was born in Pisa, Italy on February 15, 1564, one hundred years after Copernicus's death (Wiker, 2011). He studied medicine at the University of Pisa, but left the university in 1585 without a degree. He was, however, fascinated with the mathematics and natural philosophy courses he had taken. It is probable that the astronomy textbook Galileo studied at university was authored by the brilliant Jesuit mathematician and astronomer, Christophe Clavius. Clavius's textbook employed Ptomaic arguments in opposition to heliocentrism, but would have been Galileo's first exposure to Copernicanism (Hannam, 2011).

During his university studies, Galileo was also exposed to the works of the Merton Calculators, John Buridan, Nicole Oresme, Nicholas of Cusa, and other leading Scholastics (Hannam, 2011). Their well formulated calculations concerning mechanics would be indispensable to Galileo, as his thinking developed (Jaki, 1990; Stark, 2003). Galileo was also introduced to Aristotle's natural philosophy and was most intrigued by Aristotle's theory of motion (Hannam, 2011).

An early biography of Galileo claims that he was the first scientist in history to disprove the Aristotelian dictum: heavy objects fall faster than light objects (Hannam, 2011; Jaki, 1990). He is said to have climbed the leaning Tower of Pisa with a group of his students, where he simultaneously dropped two lead balls of different weights. Much to the dismay of the covey of Aristotelian professors observing the experiment, the lead balls are said to have hit the ground at the same time. Thus, it is commonly claimed that Galileo proved the Aristotelian dictum wrong, and, if that were not enough, Galileo has been credited with being the first person in history to have actually conducted an experiment. Galileo is said to have been the first person in history to demonstrate the superiority of the experimental method over mere rational analysis by philosophers, as had been originally proposed by the Greeks (Hannam, 2011; Jaki, 1990; Lindberg, 1992).

Although Galileo was definitely not the first person in history to conduct an experiment, his personal notes indicate that about that time he was, indeed, dropping wooden and lead balls simultaneously (Hannam, 2011; Jaki, 1990; Lindberg, 1992). However, his results indicated that the lead balls hit the ground first. More specifically, Galileo recorded that in the beginning of the fall the wooden balls started to plummet faster, but during the course of the fall the lead balls overtook them and hit the ground first. Galileo's results indicate that his experiments were flawed because his results are inconsistent with the reality of modern physics. It is interesting that while Galileo was performing his experiments with free-falling objects, Aristotelian professors of Pisa were also conducting similar experiments and their results were also inconsistent with the findings of modern physics (Hannam, 2011).

Several theorists had disproven Aristotle's dictum concerning free falling bodies long before Galileo lived (Jaki, 1990; Lindberg, 1992). A thousand years before Galileo, John Philoponus had experimented with free-falling objects and recorded his accurate results, which demonstrated that free-falling bodies of different weights fall at the same speed (Hannam, 2011). Also, three centuries before Galileo, Thomas Bradwardine's calculations revealed that the principles that govern free-falling bodies would even hold true in a vacuum (Hannam, 2011). In 1586, decades before Galileo began his experiments, a Dutch engineer, Stevin (1548–1620), published his experimental results, which were consistent with those of Philoponus and Bradwardine. Stevin's described his experiment and results as follows:

> The experiment against Aristotle is this: let us take (as the very learned Mr Jan Cornets de Groot, most industrious investigator of the secrets of nature, and myself have done) two spheres of lead, one ten times larger and heavier than the other, and drop them together from the height of thirty feet on to a board or something on which they give a perceptible sound. Then it will be found the lighter will not be ten times longer on its way than the heavier but that they fall together on to the board so simultaneously that their two sounds seem to be one and same (Hannam, 2011, p. 305).

Galileo was also familiar with several books written by Jesuits concerning motion (Hannam, 2011), as well as the work performed two centuries earlier by John Buridan, who had also successfully challenged Aristotle's law governing free-falling bodies (Grant, 2002; Jaki, 1990; Lindberg, 1992; Wiker, 2011). In summary, several natural philosophers had addressed the question of falling objects, published their results in opposition to Aristotle, and their results were commonly known throughout the scholarly community, well before Galileo's lifetime (Hannam, 2011; Jaki, 1990; Lindberg, 1992). Nonetheless, conflict theorists still echo the legends that Galileo was the first to prove Aristotle's dictum on free falling bodies wrong (Jaki, 1990; Lindberg, 1992) and also claim that Galileo was the first person in history to have performed an experiment (Hannam, 2011; Jaki, 1990; Lindberg, 1992).

Mean Speed Theorem and Falling Objects

Galileo had not yet learned how free-falling bodies actually move, but decades earlier a Spanish Dominican priest, Domingo de Soto (1494–1560), had resolved the problem (Hannam, 2011). Domingo de Soto traveled to the University of Paris to study theology, but like all university students of the period, he first took courses in mathematics and Aristotle's philosophy. In Domingo's time, the tradition of physics at the University of Paris was still very strong and the 14th century works of John Buridan still maintained a place of prominence.

In 1545, while in Italy to attend the Council of Trent, Domingo de Soto learned about the works of natural philosophers who were critical of Aristotle's theory of motion (Hannam, 2011; Woods, 2005). After returning to Spain in 1551, he published his own book on Aristotle's physics, wherein he successfully applied the Mean Speed Theorem that had been developed by the Merton Calculator's and graphed by Nicole Oresme two centuries before, to accurately describe how objects fall under the force of gravity (Lindberg, 1992). Domingo was the first to apply the Mean Speed Theorem to falling objects. His textbook was distributed widely throughout Europe and Galileo was a beneficiary of Domingo's work.

Catholics, Protestants, and Galileo

University scholars had attempted to ascertain the strengths and shortcomings of Aristotle's methodology for centuries, in order to help explain exactly how to relate his ideas to the natural world (Hannam, 2011; Hess & Allen, 2008; Lindberg, 1992). Galileo entered the debate at the end of that tradition (Jaki, 1990). Hannam (2011) observed, "Essentially, Galileo believed that a scientific proposition was proved if it could be derived from properly grounded causes and then demonstrated by experience" (p. 309), but Galileo didn't receive that understanding from Aristotle. He was the beneficiary of the foundational principles of empirical scientific investigation that had previously been formulated in the 13th century by Robert Grosseteste, Roger Bacon, and St. Albert the Great (Woods, 2005).

Today, modern science acknowledges that nothing is ever proven absolutely because new discoveries and evidence may arise that disprove a theory (Hannam, 2011). For example, modern science has shown that Newton's laws and Kepler's model of the solar system are not precisely correct and that Einstein's theory of gravity has supplanted that of Newton's (Spitzer, 2010). Galileo's dogmatic assumption that scientific propositions can be verified with undeniable certainty would eventually become a significant contributing factor to his infamous troubles (Hannam, 2011; Walsh, 1915; Woods, 2005).

In 1597, Galileo studied a recently published book by Kepler, which he had received from a mutual acquaintance (Hannam, 2011). Although Kepler was unfamiliar with Galileo and his work, he was pleased to have an ally in his acceptance of Copernicanism, so wrote to Galileo and presented him with a few additional copies of his book. Unfortunately, Galileo freely borrowed from Kepler's *Mysterium cosmographicum* and used parts of the work in his own publication without citing his source (Johannes

Kepler, 2013). In fact, Galileo was notorious for failing to cite his sources (Woods, 2005). Inexplicably, Galileo never applied Kepler's most important discovery, elliptical planetary orbits, which ultimately contributed to substantially completing the Copernican model (Jaki, 1990; Lindberg, 1992).

As detailed above, a great deal of very significant theoretical work in physics had taken place between the time of Copernicus and Galileo (Jaki, 1990). Although heliocentrism had been continually denounced by Protestants in the period (Dowd, n.d.; Hess & Allen, 2008; Hagen, 1908; Osborn, 2010; Wiker, 2011), Catholic universities had never ceased to analyze, debate, and further develop various aspects of Copernicus's theory. Moreover, they did so without any ecclesial opposition (Woods, 2005).

In 1597, long before the controversy surrounding Galileo and heliocentrism ensued, a Spanish Friar by the name of Didacus a Stunica, once again reiterated the fifth-century teaching of St. Augustine regarding biblical exegesis, and yet again cautioned against a literal reading of Scripture (Hannam, 2011; Jaki, 1990; Woods, 2005). Stunica was another in a long line of Catholic theologians who asserted that passages that seem to indicate that the Earth is motionless could easily be understood allegorically. Nicole Oresme had, of course, also restated the same exegetical argument in the mid-14th century (Hannam, 2011; Duhem, 1911). Nonetheless, the Protestant Reformers' position reflected a literal reading of Scripture and the pressure on the Catholic Church to disavow heliocentrism was growing (Wiker, 2011; Woods, 2005).

Galileo's Telescopic Discoveries

Following the 1610 release of Galileo's *Sidereal Messenger* (i.e., *Starry Messenger*), which described his discoveries made with the latest scientific instrument – the telescope – Galileo became an instant international sensation (Hannam, 2011; Woods, 2005). The very day of its publication – England's ambassador to Venice wrote home and surmised that Galileo "runs the risk of either being extremely famous or exceedingly ridiculous" (as cited in Hannam, 2011, p. 317). The telescope had been invented a few years earlier in Holland by Hans Lipperhey, but Galileo built his own and improved on its magnifying power and clarity. Having heard reports of Lipperhey's invention, Galileo quickly grasped the relevant optics required for the telescope, studied the laws of refraction over the course of one single night, and constructed a telescope which magnified three times. He soon, however, improved the magnifying power to thirty-two times that of the naked eye (Gerard, 1909).

His first discovery indicated that a multitude of stars exist that cannot be seen with the naked eye (Hannam, 2011; Woods, 2005). He then observed four small objects orbiting around the planet Jupiter. Aristotle had surmised that the heavenly bodies must be immutable, perfect spheres, but Galileo observed that the surface of the moon was imperfect with craters and mountains. Although Galileo was not the only person to explore the cosmos with the new telescope, he was the first to publish his findings. He continued to publish a steady flow of new discoveries (Gerard, 1909), which at least in the public mind, kept him on the leading-edge of astronomy (Hannam, 2011).

Within a year of the publication of his *Sidereal Messenger*, Galileo announced that Saturn has "ears" (Hannam, 2011). He also detailed the phases of Venus, noting its similarities to the phases of the moon. Galileo observed that on some occasions as he peered through his telescope, Venus appeared to be almost a flat disk, but at other times Venus looked to be a semi-circle, and at other times only a small slice of Venus was visible. By identifying the phases of Venus, Galileo had discovered that Venus was orbiting the sun, not the earth (Hannam, 2011). The observation of the phases of Venus and the orbiting moons of Jupiter were indications that Ptolemy's geocentric model of the universe was inaccurate. The phases of Venus, the four moons orbiting Jupiter, and the imperfection of the heavenly spheres were Galileo's most significant observational discoveries in reference to heliocentrism. These discoveries were not proof of heliocentrism, but definitely indications of its validity (Hannam, 2011; Hess & Allen, 2008; Woods, 2005).

Fortunately for Galileo, he had constructed his telescope in such a way that it was strong enough to make the aforementioned observations, but unfortunately his telescope was better than everyone else's (Hannam, 2011). As a result, other members of the scholarly community experienced great difficulty in confirming his findings, so began to discount his discoveries. Galileo could see things that were not apparent to other observers and to further exacerbate the issue, several of Galileo's peers had apparently decided in advance that he was misguided. For example, Galileo's colleague at the University of Padua was the university's professor of Aristotelian philosophy, Cesare Cremonini. Predictably, Cremonini was unreceptive to Galileo's claims of discoveries that diverged from Aristotle's teachings. Cremonini was such a staunch Aristotelian thinker that he repeatedly refused – even to the Inquisition – to contradict Aristotle's denial of the soul's immortality. Before long, Cremonini voiced his objections to the whole question of the telescope: “I do not wish to approve of claims about which I do not have any knowledge, and about things which I have not seen,” and added, “…to observe through those glasses gives me a headache. Enough! I do not want to hear anything more about this” (as cited in Hannam, 2011, p. 318). Headaches aside, it seems more likely that Cremonini was simply expressing his frustrations in the displacement of Aristotle's notions about physics.

Another professor of Aristotelian philosophy, Giulio Libri from Pisa, was seemingly more honest than his colleague, Cremonini (Hannam, 2011). It seems that Libri was genuinely experiencing difficulties observing the moons of Jupiter through the telescope available to him. Libri died before he was able to confirm Galileo’s discoveries and Galileo's sarcasm – the same sarcasm that would haunt him throughout his career – surfaced, as he commented, “Never having wanted to see [the moons of Jupiter] on earth, perhaps he’ll see them on the way to heaven” (as cited in Hannam, 2011, p. 319). Galileo's comment is possibly the source of the persistent fable that claims certain key figures refused even to peer through the telescope. But in fact, there is no historical evidence indicating that any person refused to do so (Hannam, 2011).

The debate continued between Galileo and the Aristotelian natural philosophers, but for the Church, the most important opinion was that of the brilliant Jesuit mathematician and astronomer, Christophe Clavius (Hannam, 2011). In the beginning, Clavius was skeptical of Galileo's claims. The telescope was a new instrument in 1610 and very few people had any idea how it worked. In fact, to those contemporaneous with the events were not sure if the telescope was magnifying or distorting the images. Clavius peered through a telescope that had been constructed by one of his students, but it lacked the power to verify Galileo's claims. Clavius then instructed his student to work to improve the telescope and the revised telescope produced the power and clarity Clavius needed to confirm Galileo's discoveries.

A fellow Jesuit, Cardinal Bellarmine, wrote a letter to Clavius inquiring as to whether he could corroborate Galileo's discoveries (Hannam, 2011). Clavius responded with the news that he could indeed confirm Galileo's discoveries, although, at that early stage he was unwilling to speculate as to how the results should be understood. Clavius also wrote to Galileo to inform him that he and his fellow Jesuit astronomers had confirmed his discoveries and to offer their congratulations to the Florentine (Woods, 2005).

Galileo Celebrated in Rome

In 1611, Galileo was invited to Rome, where Church prelates, scholars, and prominent secular figures greeted him with great enthusiasm and praise for his discoveries (Hannam, 2011; Woods, 2005). Galileo wrote to a friend and expressed his pleasure, "I have been received and shown favor by many illustrious cardinals, prelates, and princes of the city" (as cited in Woods, 2005, p. 69). He was honored with an audience with Pope Paul V and the Jesuits of the Roman College requested his presence at a day of celebration in his honor (Woods, 2005). One of the Jesuit astronomers who lauded Galileo's discoveries, during his visit to Rome, was Father Grienberger, who had personally verified Galileo's discovery of the orbiting moons of Jupiter. Grienberger would also soon invent the equatorial mount, which is a device that secures and rotates a telescope on an axis parallel to the Earth's axis. Grienberger was also instrumental in the development of the refracting telescope that is still in use today (p. 70).

Galileo had energized the discipline of astronomy and his discoveries launched a wave of enthusiasm for telescopic astronomical observation (Woods, 2005). In 1611, Kepler promptly elaborated on precisely how the telescope worked and suggested improvements that were grounded in his experiences in both mathematics and optics (Hannam, 2011). Christophe Clavius, who was now in the twilight of his career, added a section to his widely distributed astronomy textbook, wherein he outlined Galileo's discoveries and concluded, "astronomers ought to consider how the celestial orbs should be rearranged to model these phenomena" (as cited in Hannam, 2011, p. 319). Clavius had long adhered to the Ptomaic model that had been widely accepted by scholars for fourteen hundred years, but he proved to be intellectually honest. Prior to his imminent death, in light of Galileo's discoveries which pointed to the truth of heliocentrism – although far from confirmed – Clavius indicated that reform was necessary (Hannam, 2011).

In 1611, the debate among scholars was not centered on deciding between only the heliocentric and the geocentric models of the universe (Hannam, 2011; Jaki, 1990; Wiker, 2011; Woods, 2005). The Lutheran astronomer, Tycho Brahe, had put forward his model as an alternative to the Copernican system. He advanced a geo-heliocentric model in which the five planets revolve around the sun, which in turn revolves with the moon around the earth (Hess & Allen, 2008). Although Tycho's system was cumbersome – like Ptolemy's it included epicycles and eccentrics to account for planetary orbits – it was acceptable within the Protestant community because the earth was stationary. For a time, Tycho's system was the most widely accepted model. His system also satisfied the vast majority of astronomers of the time because it appeared to be consistent with the latest telescopic observations. That is, telescopic discoveries seemed to indicate that the five planets revolve around the sun, but had certainly not demonstrated that the earth revolves around the sun as well. Again, stellar parallax had not been observed and would not be until 1838, so the system devised by Tycho Brahe, the most famous astronomer of the day, was the most logical choice (Wiker, 2011).

Due to his newfound notoriety, Galileo accepted the position of official mathematician to the Grand Duke of Tuscany, Cosimo I de Medici (Hannam, 2011, Hess & Allen, 2008; Jaki, 1990). Galileo continued to enjoy great fame, security, and notoriety and was hailed throughout Europe as a great discover. He first advocated the Copernican system in print in his 1612 publication, *Letters on the Sunspots,* and among the many enthusiastic letters of congratulations he received was a letter from Cardinal Maffeo Barberini, who later became Pope Urban VIII (Woods, 2005).

The Galileo Affair

In 1543, Copernicus finally relented and published his heliocentric model, after repeated requests from members of the Catholic Church hierarchy (Gassendi & Thill, 2002). In the 90 years between Copernicus's 1543 publication and Galileo's sentencing by the Inquisition, which included the reign of fifteen different popes, the Catholic Church never voiced any opposition to the Copernican system (Woods, 2005). Quite the reverse, Church officials lauded Copernican's heliocentric system as an elegant theoretical model that accounted for celestial phenomena slightly more accurately than Ptolemy's geocentric model (Wiker, 2011; Woods, 2005). However, Copernicus's model was far from confirmed, and thus, could not yet be regarded as literally true. Nevertheless, Galileo believed otherwise. He believed Copernicanism was factually true and did not consider it a mere hypothesis to be used for accurate predictions of celestial phenomena. Unfortunately, Galileo lacked adequate verifiable evidence to prove the truth of Copernicanism and never found it in his lifetime (Hess & Allen, 2008).

The debate over Copernicus's heliocentric model, Ptolemy's geocentric model, and Tycho Brahe's geo-heliocentric model had both scientific and theological implications (Hannam, 2011; Hess & Allen, 2008; Wiker, 2011; Woods, 2005). The leading Protestant Reformers had simply rejected the Copernican model because it contradicted their interpretation of scripture. They had no need for any other evidence (Hess & Allen, 2008; Hagen, 1908). But the Catholic Church and Catholic academics, continually debated the merits of each of the three models as plausible theories because scientific methods available at the time were simply incapable of establishing the literal truth or falsehood of any of the three (Wiker, 2011; Woods, 2005). Galileo's continued insistence of the literal truth of Copernicanism, in light of continuing scriptural objections from Protestants and some Catholic theologians, finally culminated to the point in which the Catholic Church was forced to act (Hess & Allen, 2008; Wiker, 2011; Woods, 2005).

In 1615, the Inquisition asked Galileo for scientific proof to substantiate the Copernican model and when he could not produce the evidence they ordered him to stop teaching heliocentrism as literally true (Gerard, 1909). He was; however, free to teach Copernicanism as a hypothesis (Woods, 2005). Galileo agreed and promised to comply. Even so, Cardinal Bellarmine, the most influential member of the College of Cardinals at the time, made it clear that those passing judgment against Galileo did not consider the matter closed or the decision as final and irrevocable. In April of 1615, after the decision was handed down by the Inquisition, Bellarmine wrote to a friar by the name of Foscarini, who was an important ally of Galileo. Bellarmine urged that because sufficient proof to confirm the Copernican model as literally true was not available, Galileo should be satisfied with representing the system as a practical means of explaining celestial phenomena. But in light of the religious climate immediately following the Protestant Reformation, Bellarmine again counseled that Galileo should not categorically assert what seemed to controvert scripture. Echoing the position of St. Augustine of the fifth-century, Bellarmine stated it was perfectly acceptable to maintain Copernicanism as a working hypothesis and added:

> I say that if a real proof be found that the sun is fixed and does not revolve round the earth, but the earth round the sun, then it will be necessary, very carefully, to proceed to the explanation of the passages of Scripture which appear to be contrary, and we should rather say that we have misunderstood these than pronounce that to be false which is demonstrated (as cited in Gerard, 1909, para. 14; as cited in Woods, 2005, p. 72).

Bellarmine's theoretical openness in relation to interpretation of scripture in light of new scientific evidence was consistent with the long-standing Catholic position (Augustine, 415/1982). More than eleven centuries before, St. Augustine insisted that the Bible is not a science book: "One does not read in the Gospel that the Lord said: ‘I will send you the Paraclete who will teach you about the course of the sun and moon.’ For he willed to make them Christians, not mathematicians" (as cited in Catholic Answers, 2004, para. 12). Thomas Aquinas’s reaffirmed the same idea concerning scripture in the 13th century:

> First, the truth of Scripture must be held inviolable. Secondly, when there are different ways of explaining a scriptural text, no particular explanation should be held so rigidly that, if convincing arguments show it to be false, anyone dare to insist that it still is the definitive sense of the text. Otherwise unbelievers will scorn Sacred Scripture, and the weight to faith will be closed to them (as cited in Woods, 2005, p. 73).

The same approach to scripture had been advocated by Nicole Oresme in the 14th century and in 1584, a Spanish Friar, Didacus a Stunica, noted that certain scriptural passages can just as easily be used to show the earth moves (Duhem, 1911; Hannam, 2011; Jaki, 1990; Woods, 2005).

The Catholic Church was amenable to reinterpreting the few scriptural passages that seemed to indicate the earth is stationary, but only if scientific evidence to the contrary could be provided (Woods, 2005). The difficulty was that Galileo and his Jesuit astronomer allies, who were also trying to confirm the truth of heliocentrism, could not produce sufficient evidence to justify a reinterpretation of scripture. Lacking sufficient evidence, Galileo argued that the movement of the tides constituted proof of the earth's motion, but the Jesuits had long known that was not the case. Most importantly, Galileo could not account for the lack of stellar parallax (i.e., the difference in direction of a celestial object as observed from two widely separated points in the Earth's position), which had been the geocentrist's principal objection since the time of Aristotle (Hess & Allen, 2008).

One year later, in 1616, in response to the continuing Protestant claim that the Catholic Church disregards Sacred Scripture, which, at least in part, endured because of Galileo's newfound fame, Church authorities took further action concerning Copernican's model (Wiker, 2011). "The Church did not ban Copernicus's work but suspended its publication until it could be corrected" (p. 43) and yet again ordered Galileo to cease teaching heliocentrism as literally true (Woods, 2005). Four years later, in 1620, the Church's Congregation of the Index released a "corrected" version of Copernicus's *De revolutionibus,* wherein nine sentences were to be omitted or expressed hypothetically before it could be read freely by all (Hagen, 1912; Hess & Allen, 2008; Wiker, 2011).

Galileo then, in spite of warnings by his friends, began to delve into philosophical and theological territory that was not only enormously controversial at the time, but outside of his professional expertise (Catholic Answers, 2004, para. 11). Beyond his insistence to teach Copernicanism as factually true, his 1623 publication of *The Assayer* brought about the second factor that brought him under suspicion. In *The Assayer*

Galileo openly advocated the materialist position of the ancient pagan philosopher Democritus (Wiker, 2011). Lindberg (2011) described the incompatibility of the atomist philosophy with Christian doctrine:

> What is important about the atomists is their vision of reality as a lifeless piece of machinery, in which everything that occurs is the necessary outcome of inert, material atoms moving according to their nature. No mind and no divinity intrude into this world. Life itself is reduced to the motions of inert corpuscles. No room exists for purpose or freedom; iron necessity alone rules. This mechanistic worldview would fall out of favor with Plato and Aristotle and their followers (as cited in Lindbergh, 1992, The Milesians and The Question of Underlying Reality section, para. 8).

The first four centuries of Christianity are replete with denunciations of the materialist doctrines of Epicurus and his disciple Lucretius by such early Church Fathers as, St. Athanasius, St. Gregory of Nyssa, St. Basil, St. Ambrose, and St. Augustine (Wiker, 2011). For the Church, the all-too-familiar materialist philosophy came with further implications that are incompatible with Christianity, "If atoms and the void are the only reality, then there are no such things as immaterial souls. We human beings are mere agglomerations of atoms, an accident of their material substance" (p. 49). Predictably, espousing a philosophy in opposition to Christian theology within a century of the onset of the Protestant Reformation brought Galileo under further suspicion by Church officials.

Wiker (2011) noted that to our modern-day sensibilities, Galileo's statement of his materialist position may not be any cause for alarm. But in a climate wherein Europe was only a hundred years removed from the Protestant Reformation, which had divided European Christianity in almost half and initiated wars, such as the Peasant Wars in Germany, which resulted in the deaths of a quarter of a million people alone (Crocker, 2001), Galileo's materialist statements was not be taken lightly (Wiker, 2011). Consider too that the entire Protestant Reformation was initiated by Martin Luther, an obscure German monk who lived in a secluded monastery. Whereas, Galileo was by that time an internationally famous scientist, whose previous positions had already garnered much attention and drawn considerable negative responses from the Protestant world. The Catholic Church’s patience with Galileo by that time was waning (Stark, 2003; Woods, 2005).

Nonetheless, Galileo continued with his work and one year later, in 1624, was once again received as a distinguished guest in Rome (Woods, 2005). The pope gave Galileo several gifts and awarded him two metals, along with a statement promising further patronage of his work. He then hailed Galileo as a man “whose fame shines in the sky and is spread over the whole world" (as cited in Woods, 2008, p. 73). Woods noted that the pope communicated to Galileo that the Catholic Church had not and never would declare the Copernican model heretical.

Galileo’s inflexible personality was the third factor that caused him significant difficulties in his relationship with Church authorities (Hess & Allen, 2008; Stark, 2003; Woods, 2005). Galileo demonstrated an arrogance and unwillingness to concede that he lacked verifiable evidence to prove the truth of Copernicanism. Moreover, he stubbornly ignored important discoveries by his contemporaries. Artigas (2003) observed that Galileo's rigid belief that only perfectly circular orbits could permit natural and unending celestial motion, he discounted Kepler's brilliant discovery of elliptical planetary orbits, which enabled much more accurate calculation of planetary motion (as cited in Hess & Allen, 2008, p. 48).

In 1618, Galileo's unyielding personality surfaced when three comets soared across the skies of Europe (Hannam, 2011). Aristotle had proposed that comets were mere atmospheric phenomena. But a Jesuit astronomer, Horatio Grassi, precisely measured the parallax of one of the comets and determined that its path was definitely above the moon and not an atmospheric phenomenon. Tycho Brahe and other astronomers agreed with Grassi's finding, but strangely, Galileo refused to accept Grassi's findings and pressed one of his students to write a refutation. The refutation discounted Grassi's discovery and even ridiculed the notion of proposing anything definite about comets. Galileo's conflict with Grassi ran concurrent with another dispute he was having with yet another Jesuit over who first discovered sunspots (Hannam, 2011). In spite of these episodes, the Jesuits remained ardent supporters of Galileo before, during, and after his troubles with the Inquisition (Hess & Allen, 2008; Woods, 2005).

Clearly, however, Galileo's biggest blunder came to light in 1632 with the publication of his *Dialogue concerning the Two Chief Systems of the World* (Hannam, 2011; Hess & Allen, 2008; Woods, 2005). Through his pen he managed to alienate the very person who had urged him to publish the book – his friend and longtime enthusiastic supporter, Pope Urban VIII.

On several occasions, Galileo had been invited to the Vatican and enjoyed long audiences with the pope, wherein they strolled the papal gardens and discussed Galileo's theories and discoveries (Woods, 2005). In one such meeting in 1623, the pope expressed his opinion that, "It would be excessively bold if someone should want to limit and compel divine power and wisdom to a particular fancy of his" (as cited in Hess & Allen, 2008, p. 49). In the same meeting, Galileo requested permission from his longtime friend to write a book on the heliocentric model, the pope gave his permission, but the expressly cautioned Galileo against advocating any particular position. He was to only present arguments in favor and against heliocentrism. Galileo soon published his *Dialogue concerning the Two Chief Systems of the World* (Catholic Answers, 2004).

In his book, Galileo portrayed a debate over heliocentrism and inserted the words of the pope in the mouth of *Simplicio* (i.e., *the Simpleton*) (Hess & Allen, 2008, p. 48). To complicate matters more, the book was not written in Latin, but the Italian language for the masses. Predictably, the pope was extremely insulted at having been betrayed in print by his friend, fellow Florentine, whom he had supported. Moreover, the pope had instructed Galileo to present his arguments as a hypothesis, not as an established fact, but in keeping with his personal history, Galileo ignored that advice (Woods, 2005). The Roman authorities interpreted Galileo’s work as a direct challenge and regarded it as plainly inconsistent with his promise to cease proposing Copernicanism as an established fact (Gerard, 1909).

Galileo had managed to exhaust any patience Church officials had shown, and unfortunately, in 1633, eighteen years since he first agreed to teach the heliocentric system as a hypothesis, he was declared suspected of heresy and ordered to refrain from publishing on Copernicanism (Woods, 2005). He was put on trial, found guilty of heresy, and placed under house arrest for the remaining ten years of his life (Hess & Allen, 2008). The Inquisition ruled that he was "'vehemently suspected of heresy" and sentenced "to incarceration at the pleasure of the tribunal and to recite the Seven Penitential Psalms once a week for three years" (Gerard, 1909, para. 16). The historian, Giorgio de Santillana, who is no advocate for the Church, concluded: "We must, if anything, admire the cautiousness and legal scruples of the Roman authorities" (Catholic Answers, 2004, para. 20). Galileo's daughter, who was a nun, helped him perform his penance. He published his most famous work, while under house arrest, entitled *Discourse on Two New Sciences,* remained a Catholic, and continued to attend Mass for the remainder of his life (Hess & Allen, 2008).

Langford (1966) offered a valuable summation of Galileo's position during the controversy:

> Galileo was convinced that he had the truth. But objectively he had no proof with which to win the allegiance of open-minded men. It is a complete injustice to contend, as some historians do, that no one would listen to his arguments, that he never had a chance. The Jesuit astronomers had confirmed his discoveries, they waited eagerly for further proof so that they could abandon Tycho's system and come out solidly in favor of Copernicanism. Many influential churchmen

believed that Galileo might be right, but they had to wait for more proof (as cited in Woods, 2005, p. 71).

It is not wholly accurate to characterize Galileo as a "prisoner." His Protestant biographer, von Gebler, noted:

> One glance at the truest historical source for the famous trial, would convince any one that Galileo spent altogether twenty-two days in the buildings of the Holy Office (i.e., the Inquisition), and even then not in a prison cell with barred windows, but in the handsome and commodious apartment of an official of the Inquisition" (as cited in Gerard, 1909, para. 17).

Wiker (2011) observed that during the trial Galileo spent his time staying in his prosecutor's the six-room apartment that was located within the Inquisition Palace. The apartment came complete with a servant. Galileo was later allowed to move to the Medici family palace in Rome. He first spent his house arrest at the archbishop's residence in Siena, but was allowed to move to his personal residence at Artetri, near Florence, where he died in 1642 at 77 years of age (p. 45).

Galileo Never Tortured for his Convictions

In 1728, Voltaire wrote: "The great Galileo, at the age of fourscore, groaned away his day in the dungeons of the Inquisition, because he had demonstrated by irrefragable proofs the motion of the earth" (Smollett et al., 1905, p. 167). More recently, in 1980, Carl Sagan, lamented that Galileo had languished "in a Catholic dungeon threatened with torture" for his "heretical view that the earth moved about the sun" (as cited in D'Souza, 2008, p. 101). Sam Harris wrote of the Christian tradition of "torturing scholars to the point of madness for merely speculating about the nature of the stars" (Harris, 2004, p. 105). D'Souza, noted that "Daniel Dennett singles out the Catholic Church and faults its unfortunate legacy of persecution of its own scientists'" (D'Souza, 2008, p. 101). Apparently, for the sake of equality, Jakosky (1988) even alleged that "Copernicus's views were not embraced by the church" and added "the history of his persecution is well known" (as cited in D'Souza, 2008, p. 101).

Contemporaneous accounts demonstrate that reality was very different from legend (Wiker, 2011; Woods, 2005). For example, the Tuscan ambassador to the Vatican, Nicolini, was Galileo's friend and a valuable source concerning the matter, as he documented the details in regularly filed reports to the court (Catholic Answers, 2004). In a letter to the Tuscan king dated February 13, 1633, Nicolini revealed the nature of Galileo's sentence. He reported, "The pope told me that he had shown Galileo a favor never accorded to another;" then on April 16th Nicolini reported " . . . he has a servant and every convenience;" and two months later, on June 18th wrote:

> in regard to the person of Galileo, he ought to be imprisoned for some time because he disobeyed the orders of 1616, but the pope says that after the publication of the sentence he will consider with me as to what can be done to afflict him as little as possible (as cited in Catholic Answers, 2004, para. 22).

It has also been alleged that Galileo was tortured and blinded by his persecutors and that he was denied burial on consecrated ground (Gerard, 1909). Galileo did lose his sight, but from natural causes and upon his death, Pope Urban VIII sent his blessing and he was interred within the church of Santa Croce in Florence.

The trial and subsequent condemnation of Galileo did not concern Church doctrine, but was directed at the person of Galileo for his refusal to abide by the orders of the Inquisition, which had mandated that he only teach Copernicanism as a hypothesis (Gerard, 1909). In light of the volatile time following the Protestant Reformation, Hannam (2011) asserted that Galileo's trial was not the result of science, but forced by political necessity. There is no doubt the decision of the Catholic Church was unwise, but through time the Church's critics have continually overstated and embellished the circumstances. The Senior Research Fellow at Oxford, J.L. Heilbron (1999) offered a mature summary:

> Informed contemporaries appreciated that the reference to heresy in connection with Galileo or Copernicus had no general or theological significance. Gassendi, in 1642, observed that the decision of the Cardinals, though important for the faithful, did not amount to an article of faith; Riccioli, in 1651, that heliocentrism was not a heresy; Mengoli, in 1675, that interpretations of Scripture can only bind Catholics if agreed to at a general counsel; and Baldigiani, in 1678, that everyone knew all that (as cited in Woods, 2005, p. 74).

It is not remarkable that the Catholic Church of the 17th century would exercise its authority to censor certain intellectual positions (Hess & Allen, 2008). Since the fall of the Roman Empire – thirteen centuries earlier – the Church had been the initiator and protector of the intellectual culture within Christendom. The scientific progress that preceded Galileo had been accomplished owing to the patronage and under the protection of the Church (Woods, 2005). Moreover, the necessary foundation of literacy and education that precedes any possibility of scientific advancement had been established and safeguarded by the Church (Hannam, 2011; Jaki, 2000; Lindberg, 1992). As a result, "... churchmen took seriously their responsibility to protect the faithful by guarding the deposit of faith" (Hess & Allen, 2008, p. 41).

Wiker (2011) observed that the Catholic Church undeniably should not have censured Copernicus' work or condemned Galileo, but that the conflicts were not the result of the Church's animosity towards science. The Church looked to Galileo's peers in the scientific community for guidance, including the Lutheran, Tycho Brahe, and the best Jesuit astronomers of the age. Unfortunately, evidence to substantiate the truth of Copernicanism was not available at the time. Thus, the Church was siding with the experts and not attacking science and reason in order to protect the faith. Significantly, Wiker (2011) also noted that if the Church at that time had wholeheartedly accepted Copernicanism, they would have been accused of rash judgment for accepting a theory before adequate proof existed for its validity. Ironically, that is precisely the error Galileo made (Hess & Allen, 2008).

Although Galileo's insistence on the literal truth of the Copernican model was premature and led to his troubles, he undoubtedly made important astronomical discoveries that provoked future astronomers to continue exploring the heliocentric model (Hannam, 2011; Hess & Allen, 2008; Jaki, 1990; Lindberg, 1992; Woods, 2005). He maintained his enthusiasm to explore many fields of nature until the end of his life. Some have erroneously attributed advances and discoveries to Galileo for which he was not responsible, but the scope of his scientific accomplishments are, nonetheless, remarkable. He followed up on earlier experiments on falling bodies by others by conducting his own experiments and formulated the laws of falling bodies, as understood to the present. He explained and demonstrated the laws of projectiles and largely anticipated the laws of motion, which were ultimately discovered by Newton. He studied and expounded on statics, wherein he proposed the laws of equilibrium and the principle of virtual velocities. Galileo developed an early version of a thermometer and furthered the field of hydrostatics by establishing the correct principle of flotation. He also significantly improved on the telescope’s viewing capacity (Gerard, 1909). Unfortunately, his trial and subsequent house arrest have become the focal point of Galileo's career, which is extremely unfortunate in light of his extraordinary accomplishments in science.

In the century following the publication of the Copernican model, scientists, including Galileo, had made discoveries that suggested the truth of the Copernican model. However, astronomers had not yet discovered the force behind celestial motion and that perplexing force represented the final theoretical element that needed to be understood before heliocentrism could be accepted over Ptolemy's geocentric model and Tycho Brahe’s geo-heliocentric model. The theorist who discovered the nature of that force was born 100 years after Copernicus’s death.

Sir Isaac Newton

The final elements required to theoretically prove the truth of heliocentrism were provided in the 17th century by Sir Isaac Newton (Principe, 2011). Newton continued in the mathematical-astronomical heritage begun in Europe more than six centuries before by Gerbert of Aurillac, who later became Pope Sylvester II, and which was advanced by a host of natural philosophers, as is shown herein (Hannam, 2011). Newton's contributions to mathematics, astronomy, and physics are then, best understood as a continuation and flourishing of the various empirical scientific disciplines that both originated and developed in Christian Europe. That is, Newton's achievements are best understood as a continuation and natural progression in light of the collective achievements of his predecessors (Wiker, 2011), as opposed to his singular genius.

Newton, like his scientific forerunners in Europe, was also a direct beneficiary of the Christian understanding of an intelligible universe, which was a concept that had escaped all pre-Christian and some post-Christian cultures (i.e., Islamic society) (Jaki, 1990; Jaki, 2000; Reilly, 2010; Woods, 2005). Newton's career and discoveries in connection with heliocentrism are then germane to this research, which is an analysis of the historical relationship of faith and science, in light of challenges facing educators in 2014 that concern science and science curriculum content.

In 1642, which was one year after the death of Galileo Galilei, Isaac Newton was born in the county of Lincolnshire, England (Fowler, n.d.). At age nineteen, Newton began his university studies at Trinity College of Cambridge University, where he was first introduced to Aristotle's *Physics*. Newton's scientific studies also included more contemporary works by such figures as Descartes, Copernicus, Galileo, and Kepler (Principe, 2011).

By the time of his graduation in 1665, he had already begun to develop his mathematical theory that he would eventually develop into infinitesimal calculus

(Fowler, n.d.). An intense controversy later arose as to whether Newton or Leibniz first devised infinitesimal calculus, although modern scholars believe Newton and Leibniz discovered calculus independently and essentially, simultaneously (Principe, 2011). By 1667, within two years of earning his degree at Cambridge, Newton had already developed his theories on calculus, contributed to optics, developed his universal law of gravitation, and had been named a fellow of Trinity College (Fowler, n.d.).

Newton lectured on optics between 1670 and 1672, wherein his interest was in exploring the refraction of light (Fowler, n.d.). He demonstrated that white light which had been dispersed through a prism into a spectrum of colors could be recomposed into white light by way of a lens and a second prism. He developed his theory of color after discovering that color is the result of already-colored light interacting with objects, as opposed to objects generating their color from within, as had been previously assumed. Newton drew on his own discoveries in optics to develop the first reflecting telescope (Principe, 2011), which corrected the dispersion of light into color, which had plagued the refracting telescope. Scholars still consider his *Opticks*, published in 1704, as a splendid work of modern science (Fowler, n.d.).

Newton was part of a line of Christian scholars that extends back more than a thousand years, who pursued natural philosophy as a means to better comprehend and explain God’s creation (Hannam, 2011; Jaki, 2000; Stark, 2003; Walsh, 1915). He explicitly endorsed the idea that the universe is similar to a clock that is composed of many parts, created out of nothing, and continually sustained by God (Jaki, 1990), and resolutely believed that nature reflects the complexity and creativity of its maker

(Hannam, 2011). He expressed the following sentiment in the second addition of his *Principia Mathematica* of 1713:

> Blind metaphysical necessity, which is certainly the same always and everywhere, could produce no variety of things. All that diversity of organisms which we find suited to different times and places could arise from nothing but the ideas and will of a Being necessarily existing….And that is enough concerning God, to discourse of whom from the appearances of things does certainly belong to natural philosophy (as cited in Hannam, 2011, p. 349).

In 1679, long after he had developed his law of universal gravitation, Newton returned to the problem of celestial mechanics (Hess & Allen, 2008) and in 1687, he published his *Philosophiae Naturalis Principia Mathematica*, which is generally regarded as his greatest contribution to science. In his *Principia Mathematica*, Newton effectively provided the final piece necessary to theoretically illustrate the validity of the heliocentric model by demonstrating how his three laws of motion in conjunction with his law of universal gravitation, explain Kepler's laws of planetary motion (Ferngren, 2002; Hannam, 2011; Lindberg, 1992; Jaki, 1990). Friedrich Bessel's confirmation of stellar parallax in 1838 conclusively confirmed the truth of heliocentrism, but with the addition of his laws of motion and gravity, Newton had effectively substantiated the truth of the model a century and a half earlier (Hess & Allen, 2008).

Newton's three laws of physical motion provide the basis of classical mechanics: (1) the velocity of a body remains constant unless the body is acted upon by an external force; (2) the acceleration of a body is parallel and directly proportional to the net force and inversely proportional to the mass; and (3) the mutual forces of action and reaction between two bodies are equal, opposite and collinear (Massachusetts Institute of Technology, 2014).

Newton's first law is a reiteration of the law of inertia expressed by Galileo only a few decades earlier (Hannam, 2011; Jaki, 1990; Lindberg, 1992). However, in the sixth-century, John Philoponus had come very close to describing the same force in terms of a force pressed upon a thrown object. Later, in the 14th century, John Buridan had come even closer by devising his theory of impetus (Hannam, 2011). Newton did not trace his discovery back to Philoponus and Buridan, but did acknowledged Galileo's contribution to his first law. Significantly, Newton's universal law of gravitation had earlier roots as well, as it had been anticipated by Nicole Oresme in the mid-14th century (Hess & Allen, 2008). Oresme had questioned "Aristotle's doctrine of there being only one possible 'natural place' for earthly objects, one center of attraction" and "moved toward a physics of multiple centers of gravitation" (p. 22).

Newton thought it incomprehensible that the universe and everything in it could be the result of an extremely fortuitous accident of nature (Jaki, 1990). Nonetheless, although Newton was passionately religious and considered himself a Christian, his personal beliefs were exceedingly heterodox in light of both Catholic and Protestant understanding (Stark, 2003). For the latter half of his adult life, he became so obsessed with unorthodox mystical theories that he abandoned his scientific work altogether and dedicated all his efforts to abstruse theological speculations and alchemy (Hannam, 2011; Stark, 2003). For example, he became transfixed on a series of bizarre ideas, such as, that the ancient Egyptian cubit held special significance in the pattern of the universe (Jaki, 1990).

Jaki (1990) concluded that Newtonian physics could be traced first to Nicolas of Cusa's 15th century work *De staticis experimentis* and then to Oresme, although "the finished product may seem far removed from its incipient shape. Yet, if one is to trace the antecedents of Newton's definitions of motion, momentum, and inertia, the line of investigation leads inevitably to Oresme's inquiring mind" (p. 240). In essence, Isaac Newton successfully synthesized and further developed all of the knowledge, theories, and discoveries that had taken place pertaining to physics, since the time of John Philoponus in the sixth-century (Hannam, 2011; Jaki, 1990; Lindberg, 1992).

How Newton's laws specifically apply in the minute workings of the universe was explored through experiment and observation into the 20th century (Hannam, 2011). His three laws of physical motion apply beautifully to scales and speeds of everyday life, but have proven inadequate to account for all natural phenomena present in the universe. For example, Newton's laws are incapable of sufficiently explaining extremely small scales, tremendously high speeds, or exceedingly powerful gravitational fields. Einstein's theory of gravity, proposed in the early 20th century, has now supplanted Newton's gravitational theory (Spitzer, 2010). Nonetheless, Newton's laws of motion, his law of universal gravitation, and calculus, combined to provide the first universal quantitative explanation of physical phenomena (Hannam, 2011).

Christian Contribution to Heliocentrism

The Christian conviction of an utterly rational universe was markedly different from every other great culture in recorded history, including the ancient Greeks (Jaki, 2000). Every Christian thinker who contributed to the development of the heliocentric model, from the earliest Church Fathers who argued for and explained the necessity of a rational universe, to the Alexandrian Patriarch, John Philoponus, who struck the first blow to Aristotelian physics, through Copernicus and Galileo and beyond, recited the Nicene Creed on Sundays. Copernicus inherited and expressed his confidence in the ancient Christian tradition of a rational universe, which again, is a notion entirely absent in all previously described pre-Christian cosmologies. Pantheism's complete denial of the rationality of the universe provided an unstable foundation that proved entirely insufficient for even the conception of a predictable universe and ruled out even the possibility of authentic empirical investigation (i.e., science) (Jaki, 1990; Jaki, 2000; Stark, 2003; Woods, 2005).

The Christian perspective, which perceives Christ as the *Logos* was an entirely new concept that replaced the prevailing pantheistic, pan-animistic worldview and finally freed the human mind to conceive of and explore the utter and complete rationality of the universe (Jaki, 2000; Stark, 2003; Woods, 2005). Thus, Whitehead (1948) concluded that the Scholastic's insistence on nature's rationality, grounded in the Christian understanding of an Intelligent Creator, was the principal and irreplaceable factor that finally propelled the progress of science (as cited in Jaki, 2000, p. 2).

From the inception of Christianity itself, the deep-seated Christian trust in the rationality of nature was mocked and ridiculed by the pagan thinkers of ancient Greece and Rome (Spitzer, 2010). It is significantly, however, that at that early historical stage, Christians possessed little or no evidence to support such a belief in the rationality of nature. Thus, Christian thinkers embarked on a previously unimaginable quest to study the workings and intricacies of nature (i.e., science) and very early on they aspired to overturn the pagan understanding of the cosmos itself (Lindberg, 1992). The heliocentric model was perhaps the apex of their efforts to understand the workings of the cosmos.

Although, by 1687 Newton had provided the final pieces necessary to demonstrate the accuracy of the heliocentric model in a theoretical sense, the actual truth of the model was not concretely established for another century and a half. By 1838, telescopes had been improved to the point that stellar parallax was finally observed by the German mathematician and astronomer, Friedrich Bessel. Stellar parallax is the phenomenon wherein, nearby stars appear to move relative to more distant stars based on the Earth's orbital position in relation to the sun. The angle of stellar parallax is so minute because of the vast distances of the stars that is was simply impossible to detect until the mid-18th century. Thus, the heliocentric model was finally confirmed three centuries after Copernicus proposed his theory and two centuries after Galileo's death (Hess & Allen, 2008).

For many centuries, Aristotle's physics were simply taken for granted by natural philosophers (Hannam, 2011; Jaki, 2000; Stark, 2003); and then Newton's physics and speculations concerning the nature of the universe, as eternal: possessing infinite space, time, and mass points, were received as virtually dogmatically true (Spitzer, 2010). Newton's infinite universe with no beginning and no end was enthusiastically received by 18th century Enlightenment thinkers, who intended to free the world from the confines of the Christian worldview, which purported an absolute beginning to creation (Crocker, 2001; Pernoud, 1977/2000). Newton's eternal universe would not be significantly challenged scientifically, until the advent of the 20th century, and the challenges to the concept of an eternal universe would have significant implications for the next, much celebrated scientific theory to be proposed – the theory of evolution (Spitzer, 2010).

Theory of Evolution

The central research question and second subquestion herein enquire as to what importance the historical origins and progress of science can hold in informing the continuing creationist versus Darwinist conflict within education. The merits of teaching the theory of evolution in public schools has been opposed by creationists (i.e., Christians and Muslims who interpret the creation accounts in the Book of Genesis in a literal sense), since the beginning of the 20th century and continues to be contested in 2014 (NCSE, 2012). The struggle has traditionally been between creationists and Darwinists (Larson, 2003). The polarization between the two antagonists has complicated and prolonged the struggle. creationists are notorious for resisting any claims by modern science that contradict their interpretation of scripture, such as any evidence that suggests life forms have evolved since their appearance of life forms on the Earth or a geologically young Earth (i.e., usually less than 10,000 years in existence) (Marrapodi, 2012). Conversely, beginning in the mid-18th century, Darwinists have frequently ventured beyond the limits of the natural sciences and made metaphysical and theological statements about whether or not God exists, which is clearly beyond the purview of empirical investigation (Dawkins, 2006; Harris, 2004, Royal, 2006). Moreover, creationists persist in accusing anyone who proposes that an evolutionary process accounts for the development of life as an atheistic-Darwinist (Skehan & Nelson, 2000) and many Darwinists have countered by portraying all theists as young-earth, creationists (Dawkins, 2006).

Largely due to the polarizing claims on both sides of the argument, what was originally a conflict between creationists and Darwinists has now transformed into a much more general debate over the very relationship of faith and science (David & Kenyon, 1993; Larson, 2003). Particularly in this current decade, another element of the conflict has been renewed with fervor: challenges to the very existence of God or anything beyond that which is empirically verifiable (i.e., anything beyond the limits of science) (Dawkins, 2006; D'Souza, 2008; Harris, 2004). Since the Age of Enlightenment, challenges to the existence of God, along with the claim that faith and science are mutually exclusive human enterprises, has been charged by many (Draper, 1874; Pernoud, 1977/2000; Schaefer, 2011).

School boards, school administrators, teachers, and curriculum specialists are placed in the unenviable position of having to sort out the consequences of the argument (Larson, 2003). Although the debate has developed into a general debate over the authentic relationship of faith and science, the focal point of the argument still centers on the merits of teaching the theory of evolution and its status in public education (Skehan & Nelson, 2000).

In the end, the central concern is the students, who find themselves in the center of the conflict (Larson, 2003). Many students are taught evolutionary theory in school, but then hear evolutionary theory ridiculed at home or in church. Other students listen to their teachers espouse empirical investigation as the highest form of human knowledge and even ridicule the very notion of belief in God. Many students are burdened by this ongoing conflict, in light of the fact that a typical student's world is comprised of largely independent, but interrelating cultural groups. For many students, three of the most important of those cultural groups are family, school, and their faith tradition (Scheitle, 2011; Zimmerman, 2002) and for many, these three cultural groups are not in accord or literally in conflict. In keeping with the research questions herein, the hope is that a thorough examination into the origins and developments of this continuing dispute within public education will inform the debate.

Comparison of Evolutionary Theories

As a scientific hypothesis, evolution seeks to describe the natural causes of the succession and development of all plant and animal life, through a progression of geological epochs (Ayala, 2010; Muckermann, 1909). The theory of evolution is studied within a wide range of scientific disciplines, such as, geology, biology, paleontology, morphology, embryology, astronomy, bionomy, and genetics (Bowler, 2002). The evolutionary hypothesis, then, purports that all present forms of plant and animal life are essentially descendants of former species that existed in previous geological periods. For that reason the theory of evolution has also been described as the theory of descent. The theory of evolution is opposed by the theory of constancy, which asserts the permanence of all varieties of organic species. Significantly, the scientific theory of evolution does not seek to explain the origins of life forms, but rather, seeks to describe the systematic development of the various species, genera, and families, as well as describe how each evolved through natural dissent within genetic trees (Muckermann, 1909; Stark, 2003).

In actuality, although not commonly published, the empirical evidence available thus far has actually revealed the formation of new species in only a few cases and only in relation to very closely related species (Muckermann, 1909; Stark, 2003). For example, the transitional development through time of the plant genus Oenothera and the beetle genus Dimarda have been observed and sufficiently reconstructed to demonstrate the great probability of environmental adaptations amounting to an evolutionary process. The development of the horse represents an example of an evolutionary series within a mammalian family through successive geological epochs (Muckermann, 1909). Similarly, many insects, especially those who live as "guests," such as ants and termites, seem to demonstrate an adaptation to their hosts. Although, these instances represent probability of adaptation through time, as opposed to an observable genetic development. Nonetheless, although the extensive fossil record has not revealed a tree of succession in the vast majority of cases (Behe, 2007; Muckermann, 1909; Stark, 2003), the presence of evolutionary development of many systematic species has been inferred by DNA (i.e., deoxyribonucleic acid) research (Ayala, 2010).

A comparison of the available scientific proofs to determine the probability of the theory of evolution indicates that the smaller the circle of forms under consideration, the greater the probability an evolutionary process occurred (Wasmann, 1909). However, the probability of an evolutionary development becomes much weaker when a greater number of forms, such as are comprised in a class or a sub-kingdom are considered. The vast majority of scientists support a polyphyletic (polygenetic) evolutionary model over a monophyletic (monogenetic) evolutionary model because no evidence exists at this time to demonstrate that all plants and animals developed genetically from a single primitive organism. That is, at the present it is not possible to ascertain precisely how many genetic series must account for the tremendous variety of plant and animal kingdoms in existence at this time. However, some progress has been made in identifying various genetic series present in plant and animal forms (Ayala, 2010).

Notwithstanding the creationist claim of a geologically young Earth (Answers in Genesis, 2012; Hopkins, 2007), objective research within a number of independent scientific disciplines has produced demonstrable evidence that the plant and animal kingdoms presently found on Earth represent only a miniscule measure of time related to the Earth's history of existence (Wasmann, 1909). Likewise, current scientific orthodoxy views the Earth's geological development as a minute segment of time in comparison to the history of our solar system and the development of the entire universe. As a philosophical speculation, then, the theory of evolution is understood in terms of the natural processes involved in the development of the entire cosmos. That is, from a philosophical perspective, every element in the cosmos is thought to have evolved according to the laws of nature (Wasmann, 1909; Spitzer, 2010).

In itself, the theory of evolution, understood as the natural development of the universe, including all life forms, is not opposed to theism (Aquinas, 1261/1975; Ayala, 2010; Stark, 2003; Teilhard de Chardin, 1959). That is, many theists accept that a Creator could have set secondary laws in motion, which would evolve through time. Nevertheless, some espouse an atheistic evolutionary theory, which contends the entire cosmos originated and developed to its current form exclusively through natural causes, apart from the influence of a Creator (Dawkins, 2006; Flew & Varghese, 2007; Harris, 2004). At the present, the atheistic theory of evolution is incapable of accounting for the source and reason for the very existence of the natural laws, which not only govern all of nature, but are mathematically discernible (Wasmann, 1909; Spitzer, 2010). Similarly, spontaneous generation (i.e., the independent genesis of a living organism from nonliving matter) is a central tenant of the atheistic evolutionary model, but is itself, contrary to all empirical observation. Conversely, the theistic theory of evolution accounts for the origins of life as the work of the Creator, Who is also understood as the very source of the natural laws that govern the universe (Ayala, 2010; Behe, 2007; Horn & Wiedenhofer, 2008; Jaki, 2000; Spitzer, 2010).

The atheistic theory of evolution presupposes an absolute materialism, which has led some to reject the existence of and even the possibility of a Creator, as well as the immaterial human soul and led some to ridicule theism in the name of ‘science’ (Dawkins, 2006; Flew & Varghese, 2007; Harris, 2004). Ironically, the historical

Christian position opposes both atheistic Darwinism and creationism. The long-standing Christian position, since Augustine (354-430 A.D.) further developed the thought of the scriptural scholar, Origen (185-253 A.D.), has overwhelmingly maintained that although the universe had come into being in a single creative act, God had instilled *rationes seminales* (i.e., *rational seeds*) in nature that would, over time, bring forth life in its current diversity(Hess & Allen, 2008). Thus, Christianity has long-held that God may have chosen to create through an evolutionary process, guided by secondary causes (i.e., the mathematical laws of nature). For Christians then, it follows that the immaterial human soul originated through a singular creative act, outside of the physical evolutionary process, as it is not comprised of matter (Aquinas, 1261/1975; Augustine, 415/1982; Wasmann, 1909; Spitzer, 2010).

Evolutionary Theory and Physics

In keeping with the intentions of the research questions herein, which necessitate researching the historical development of science and its relation to faith for the purpose of informing the continuing creationist versus Darwinist debate, the implications within physics for evolutionary theory are crucial. Physics and the theory of evolution are inherently linked, as cosmologists advance, scrutinize, and test new models concerning the characteristics of the known universe (Hawking, 1998). One crucial factor linking the disciplines of physic and biological evolution is the concept of time, insofar as cosmologists are virtually unanimous in concluding that time began or came into existence with the universe itself (Hawking, 1998; Spitzer, 2010; Vilenkin, 2007).

The origins and age of the universe is also, of course, very significant for those involved in the creationism versus Darwinism debate and people of faith in general (Spitzer, 2010). The first reason the age of the universe is significantly linked to the theory of evolution is that it is connected to the age of the earth itself and is uniquely suited to speak to the geological time that has been available for an evolutionary process to unfold (Ayala, 2010). Secondly, most creationists attest to a very young earth and universe (i.e., less than 10,000 years old since creation) (Answers in Genesis, 2012; Marrapodi, 2012; Hopkins, 2007), and both ideas oppose the conclusions of several scientific disciplines. Thirdly, atheists deny the Judeo-Christian conception of creation *ex nihilo* (i.e., *out of nothing*), and accordingly, normally ascribe to an eternal universe with no absolute beginning (Flew & Varghese, 2007; Harris, 2004).

In the latter half of the 17th century, Sir Isaac Newton theorized that the universe is eternal: space, time, and mass points are infinite (Spitzer, 2010). His ideas were received as virtual dogmas by the scientific community, until 20th century developments in theoretical physics, beginning with Einstein's *Theory of General Relativity*, mitigated the possibility of an eternal universe and established a boundary or absolute beginning of the known universe to be approximately 13.7 billion years ago (Jaki, 1990; Spitzer, 2010).

Prior to Newtonian physics the teleological argument or argument from design had an intuitive appeal because it was:

> …grounded in the idea that the number of higher-order complexes (producing higher-order activities such as self-motion, eyesight, intelligence, etc.) which

> could be produced by the interaction of simpler constituents is extremely remote by comparison to the number of non-productive combinations of those simpler constituents (Spitzer, 2010, p. 5).

However, in Newton's eternal universe hypothesis, wherein space, time, and mass points were thought to be infinite, philosophers and cosmologists began to reason that higher-order complexes producing higher-order activities, although extremely improbable, could certainly develop if given infinite time, space, and mass. Virtually any combination of events is possible in an infinite universe and probability equations become meaningless when an infinite number of possibilities are inserted into the equation. As Newton's eternal universe was overwhelmingly accepted by the scientific community, the teleological argument or argument from design was simply not seriously considered by cosmologists for nearly three centuries (Spitzer, 2010).

In the early 20th century, Einstein's *General Relativity* described space and time as a four dimensional manifold that stretches, warps, and vibrates (Spitzer, 2010). When cosmologists describe the expanding universe, they do not simply mean that galaxies are simply flying apart from one another through preexisting space: they mean that space itself is coming into existence by stretching and expanding. Galaxies are not moving apart from one another through existing space. Rather, objects moving apart from one another are expanding the universe itself, which is stretching like a balloon (Cornell University, 2011).

The Belgian priest, mathematician, astronomer, and physicist, Fr. Georges Lemaitre, devised what would become known as the Big Bang Theory (O'Connor &

Robertson, 2008). Lemaitre synthesized three early 20th century scientific developments, which together became the foundation of his Big Bang Theory. First, Lemaitre was one of the first to realize that Einstein's gravitational theory indicated that the universe is expanding. He then noted the 1929 discovery by Hubble and Humason, who had observed that the galaxies are receding from one another. Lemaitre then applied the expansion of the universe to Einstein's *General Relativity* theory and proposed the Big Bang theory (Spitzer 2010).

In 1931, Lemaitre responded to critics of his theory in a scientific paper entitled, *Nature*, in which he wrote:

> If the world has begun with a single quantum, the notions of space and time would altogether fail to have any meaning at the beginning; they would only begin to have a sensible meaning when the original quantum had been divided into a sufficient number of quanta. If this suggestion is correct, the beginning of the world happened a little before the beginning of space and time (as cited in O'Connor & Robertson, 2008, para. 5).

In 1933, Lemaitre and Einstein delivered a series of lectures together in the state of California (O'Connor & Robertson, 2008). After listening to Lemaitre explain his Big Bang theory, Einstein rose and proclaimed: "This is the most beautiful and satisfactory explanation of creation to which I have ever listened" (as cited in para. 6).

Lemaitre deduced that looking back in time not only were the galaxies closer together, but there was actually less space – the universe itself was smaller (Spitzer, 2010). "Extrapolating back, one can deduce that all the matter in our observable universe would have been in the same place about 13.7 billion years ago," in fact, by necessity, "they had to be in the same place, because the volume of space of our presently observable universe was —13.7 billion years ago—either zero or very close to zero" (p. 16). The Big Bang theory, which is virtually unanimously accepted by contemporary cosmologists, holds that 13.7 billion years ago, all of the matter in the universe was compressed into an extremely dense, super-hot mass, which exploded and produced the continuing separation of the galaxies presently observable in Hubble's expansion (Jaki, 1990; Spitzer, 2010).

Originally, many scientists were very skeptical about Lemaitre's Big Bang theory, at least in part because it seemed too much like a theological idea, but also because some evidence seemed to mitigate the theory (Spitzer, 2010). For example, calculations of the age of some stars and planets were older than 13.7 billion years. But before long that particular objection was overcome when physicists realized that the calculation of the recession speeds had been incorrect by a significant factor. The breakthrough that ultimately convinced the scientific community of the truth of the Big Bang theory came in 1965. Two physicists, Penzias and Wilson, confirmed the existence of Cosmic Microwave Background Radiation (CBR), which has been identified as the light that emerged from the Big Bang explosion (Hawking, 1998; Spitzer, 2010).

Contemporary physicists hold that CBR was once extremely intense, but has since red-shifted into microwaves and become very faint through billions of years of cosmic expansion (Hawking, 1998; Spitzer, 2010). Very precise measurements and refined mathematical analysis of CBR demonstrate a very complex structure that is in remarkable agreement with, and thus, validated the Big Bang theory for the vast majority of theoretical physicists. Additionally, the existence of relatively small amounts of smaller elements in our universe like hydrogen and helium are also consistent with Big Bang predictions. “There are other pieces of confirmatory evidence, so that by now there is no serious doubt that the Big Bang happened” (Spitzer, 2010, p. 17). Although people still reference “the Big Bang ‘theory,’ it is no longer doubted by cosmologists that the Big Bang actually happened, i.e., that it is a historical fact” (p. 15).

Standard Big Bang Model (SBBM) cosmology is intended to describe the universe as a whole and holds two fundamental assumptions: (a) no universe existed prior to the Big Bang; (b) that part of the universe beyond the horizon (beyond the range of contemporary telescopes) looks essentially the same as the part within the horizon (Spitzer, 2010). Cosmologists have discovered no empirical evidence in opposition to either SBBM assumption. SBBM cosmology holds that the Big Bang was the beginning of time and space, so it is quite meaningless to ask what went on before the Big Bang because there was no "before" (p. 19). Physicists hold, in keeping with Einstein's *General Relativity*, wherein time and space can stretch, warp, and vibrate, that time itself is a feature of the physical universe in the same way atoms and light are features of the physical universe. Thus, time and space began to exist at the Big Bang itself (Vilenkin, 2007).

It is somewhat ironic that the first person in recorded history to assert that time came into existence at the conception of the universe was a Catholic bishop, St. Augustine of Hippo (A.D. 354-430) (Spitzer, 2010). In keeping with their belief in an eternal universe and in some cases eternally repeating cycles, pagan thinkers in St. Augustine's time (Jaki, 2000), ridiculed Christians and Jews for believing that the universe had a beginning. Pagans asked what God was doing before the beginning of the universe and wondered why he waited so long to create the world. Augustine's profound answer continues to deeply impress many modern cosmologists. Augustine asserted that there was no time "before" the beginning because time is not God, who is eternal. Time itself was created, and therefore, not eternal. Christians and Jews believe the created world has a beginning, and, in the same way, time has a beginning. Augustine told his pagan challengers: “Do not ask what [God] was doing ‘then’, there was no ‘then’ where there was no time” (as cited in Spitzer, 2010, p. 19). The theoretical physicists, Steven Weinberg, noted that it is common for physicists to quote St. Augustine’s famous discussion of time in research papers on quantum cosmology (Spitzer, 2010).

In keeping with their discipline, theoretical physicists are continually proposing speculative scenarios as alternatives to Lemaitre’s Big Bang theory (Flew & Varghese, 2007; Hawking & Ellis, 1975; Spitzer, 2010; Vilenkin, 2007). Some cosmologists have proposed highly speculative theories that suggest that the Big Bang was not the beginning itself and that time and space existed prior to the Big Bang event. These speculative theories have been referred to as “’Past-extended Big Bang Models’ or PBBMs” (Spitzer, 2010; p. 20) and the vast majority of them attract little attention because they lack empirical evidence and have consistently proven to be mathematically flawed. That is, they acknowledge the fact that the Big Bang occurred, but rather than viewing the Big Bang as the absolute beginning, they propose that it was an event in the history of our universe. Nonetheless, thus far, a completely consistent, mathematically demonstrable PBBM, wherein time had no beginning, has not been found (Vilenkin, 2007). Moreover, the majority of cosmologists suggest that such a model is also unlikely to be found in the future (Vilenkin, 2007).

Candidate Scenarios with No Beginning

The theory of blind, random, and purposeless evolution would be greatly enhanced if the eternity of the universe could be established because, in essence, the teleological argument or argument from design would become inconsequential, as it did under the influence of Newtonian physics (Spitzer, 2010). Thus, whether or not the universe can be shown to have an absolute beginning in time is a question that interests both scientists and theologians and is a question uniquely characteristic of the relationship of faith and science. Again, an infinite universe could potentially give rise to any combination of events and an inexhaustible timeline would lend tremendous weight to the theory of evolution. Thus, there is no shortage of attempts to formulate cosmological models that preclude an absolute beginning and although most garner little attention, theorists have given serious consideration to a few possible alternative models (Vilenkin, 2007).

One speculative model that postulates no beginning is usually termed the "bouncing universe" model (Spitzer, 2010). Within the "bouncing universe" hypotheses, it is supposed that the universe has undergone several cycles of continuous expansion and contraction previously and will perhaps continue to expand and contract into eternity.

The "bouncing universe" model holds that the Big Bang was merely the beginning of the present cycle (p. 20).

Another speculative scenario, the "eternal inflation" model, holds that the observable universe constitutes a part of an island or isolated section within a vast unobservable universe (Spitzer, 2010). It has been proposed that although the observable island or isolated section takes billions of years to appreciably increase in size, the areas between sections is undergoing incredible "exponential expansion – in fact, doubling in size every 10 to 40 seconds in a typical version of the scenario" (p. 20).

Another highly speculative model "supposes that our four dimensional universe (three space dimensions plus one time dimension) is just a slice of a universe with more dimensions" (Spitzer, 2010, p. 20). There are many speculative scenarios in particle physics that hypothesize a series of higher dimensions, such as, supergravity theories and superstring theory. Einstein also worked on extra dimensional theories for a time. In fact, the only way known to unify Einstein's theory of gravity with quantum mechanics, in a mathematically consistent respect, requires "extra" space dimensions and that process is known as superstring theory (p. 20).

The “emergent universe” or static seed theory represents yet another speculative model, which proposes that the universe existed in a static condition before starting to expand, which accounts for the current observable Hubble expansion (Magis Video, 2012). There is no indication of the length of time that the universe may have sat in a static condition prior to beginning the now observable expansion.

Still another, speculative alternative to the Big Bang model that has garnered significant interest from cosmologists is usually referred to as the multiverse theory (Flew & Varghese, 2007; Spitzer, 2010). The multiverse theory was developed, in part, in an effort to explain the incomprehensible odds against this universe possessing the precise universal constants necessary to support life, and as an alternative to the Big Bang theory. In the multiverse scenario, the known universe represents only one of possibly trillions upon trillions of universes in existence (Hawking, 1998). Thus, for those cosmologists interested in disproving the Big Bang model, the incredible mathematical odds against this universe containing the precise, seemingly fine-tuned, laws of nature, capable of enabling the emergence and sustenance of life, sometimes called “cosmic coincidences” or “anthropic coincidences,” can only be explained through trillions of opportunities (Spitzer, 2010, p. 23).

In response to these and other speculative scenarios, intense research and mathematical operations have been conducted by the world’s most distinguished theoretical physicists, as they work to confirm or refute these and similar hypotheses in opposition to the Big Bang Theory and an absolute beginning of the universe approximately 13.7 billion years ago (Flew & Varghese, Hawking, 1998; 2007; Spitzer, 2010). Very recent developments in theoretical physics have enabled great progress toward analysis of these and other related scenarios. For example, before 1964, the available evidence pointed to an eternal universe possessing finite space and time and quantum cosmology was not sufficient to address the issues at that time (Spitzer, 2010).

A decade later, Hawking and Ellis (1975) concluded: "The results we have obtained support the idea that the universe began a finite time ago" (p. 364).

Arguments that justify the extremely high probability that the universe and time itself had a beginning, prior to which no physical reality existed, are of two types: “(a) arguments about the possible geometries of space-time; and (b) arguments based on the Second Law of Thermodynamics” (Spitzer, 2010, p. 22).

Arguments concerning geometries of space-time concern universal constants, which determine the parameters of interaction and interrelationship among every aspect of the universe, including, space, time, and various kinds and emissions of energy (Spitzer, 2010). These universal constants are extraordinarily precise values that apply universally – in all places and times. These constants are present in a variety of forms, including, minimums, maximums, fixed quantities, ratios, units of individuation, and fixed parameters of transformation. The values of the universal constants are represented by the fundamental equations of physics, and, thus, determine the entire structure of the universe. In point of fact, theoretical physicists have mathematically established that had the values of the universal constants been even slightly higher or lower, the universe would have either been constituted by multiple black holes, one vast black hole, or an abundance of non-interacting particles, rendering the universe incapable of forming any material substance. Moreover, the probability that the universe would contain non-anthropic conditions (i.e., non-life enabling conditions) is extremely more likely than possessing anthropic conditions (i.e., life enabling conditions) (Flew & Varghese, 2007; Spitzer, 2010).

The Second Law of Thermodynamics holds that certain processes are one directional and essentially irreversible (Spitzer, 2010). For example, gases escape a pressurized environment in one direction, people age and never become younger, dishes break and do not spontaneously reassemble, and balls on a pool table do not spontaneously re-rack after the break. The reason the Second Law of Thermodynamics holds true is because, for example, there are an enormous number of possible ways pool balls can scatter on the table following impact, but very, very few possible ways for the balls to spontaneously rearrange into an organized pattern. If simply left to chance, the pool balls are vastly more likely to end up in a scattered, disorganized configuration. If the pool balls start in an organized configuration it is extremely likely that if anything causes them to change their configuration, they will become disorganized, which represents the concept of "entropy" in physics (p. 25).

Lower entropy within a system signifies more organization in physics, whereas, higher entropy within a system signifies less organization or disorganization (Spitzer, 2010). To suggest that pool balls will almost certainly not reorganize after the break, broken dishes will not normally randomly reassemble, and gasses that escape from a pressurized environment will not normally return to that environment are all probability statements. Entropy can randomly fluctuate downward, but these fluctuations are usually minute decreases and the larger the decrease downward, the more unlikely the odds of it happening. Thus, the Second Law of Thermodynamics accounts for why systems tend to run down, wear out, and decompose and entropy accounts for why perpetual motion machines are considered contrary to the laws of physics.

In terms of cosmology and the beginning of the universe, the Second Law of Thermodynamics or entropy argues against an eternal universe because if the universe is eternal and has existed forever, the universe is effectively a perpetual motion machine that never runs down or wears out (Spitzer, 2010). Moreover, the astonishing low entropy or high organization and order of the universe, as is evident in the anthropic conditions (i.e., life supporting conditions) owing to the universal constants (i.e., parameters of interaction and interrelationship among every aspect of the universe, including, space, time, and various kinds and emissions of energy), opposes the Second Law of Thermodynamics. Some have proposed, however, even if the universe were eternal into the past, the universe could eventually exhaust its energy, wherein the Hubble expansion would slow down and eventually reverse, which would lead to a collapse of the universe and could lead to a "bounce," wherein another Big Bang takes place (Spitzer, 2010). Even so, the "bouncing universe" and all other cosmological models that seek to negate an absolute beginning have since been invalidated (Flew & Varghese, 2007; Spitzer, 2010; Vilenkin, 2007).

Eternal Universe or Boundary to Beginning

In the 1960s, Penrose & Hawking developed a singularity (i.e., absolute beginning to the universe) theorem (as cited in Magis Video, 2012). Their work was later further corroborated by Hawking & Ellis (1975), who concluded: "The results we have obtained support the idea that the universe began a finite time ago" (p. 364). Later, Linde originated a new eternal inflation model or "bubble universe" scenario, which "suggested that it allows the universe to be eternal into the past, and time to have no beginning" (as cited in Spitzer, 2010, p. 34). Linde's work originally cast doubt on an absolute beginning to the universe. Then in response to Linde and others, in 1994, Arvind Borde and Alexander Vilenkin formulated a new mathematical proof for a singularity or absolute beginning of time, assuming any conceivable inflationary scenario and vacuum energy. Later, in 1997, Borde and Vilenkin found a potential exception to their own proof – albeit, an extremely unlikely exception, but an exception nonetheless. Thus, the possibility of an eternal universe was reopened. At the same time, Alan Guth set out to prove "that all known mathematical configurations of inflationary model cosmologies required a beginning" (p. 34). Nevertheless, Guth's work, although comprehensive, did not comprise a proof of the beginning in all possible inflationary models.

The breakthrough came in 2003, when Borde, Guth, and Vilenkin joined energies and formulated an elegant mathematical proof of the necessity of a boundary to past time in all inflationary universe models (Spitzer, 2010). Their proof is known as the Borde-Guth-Vilenkin Singularity Theorem or BGV Theorem. Their mathematical analysis demonstrated that any universe with a Hubble expansion greater than zero, must, by necessity, have a beginning. Borde, Guth, and Vilenkin expressed their findings as follows:

> Our argument shows that null and time like geodesics are, in general, past-incomplete [requiring a boundary to past time] in inflationary models, whether or not energy conditions hold, provided only that the averaged expansion condition $H_{av} > 0$ hold along these past-directed geodesics. This is a stronger conclusion than the one arrived at in previous work in that we have shown under reasonable

> assumptions that almost all causal geodesics, when extended to the past of an arbitrary point, reach the boundary of the inflating region of space-time in a finite proper time (as cited in Spitzer, 2010, p. 34-35).

In addition, this mathematical proof has extensive general applicability because it applies to any universe with an average Hubble expansion greater than zero, and, accordingly, applies to and disproves all eternal inflation scenarios, including Linde's "bubble universe" (Spitzer, 2010). Vilenkin explained as follows:

> We made no assumptions about the material content of the universe. We did not even assume that gravity is described by Einstein's equations. So, if Einstein's gravity requires some modification, our conclusion will still hold. The only assumption that we made was that the expansion rate of the universe never gets below some nonzero value, no matter how small. This assumption should certainly be satisfied in the inflating false vacuum. The conclusion is that past-eternal inflation without a beginning is impossible (as cited in Spitzer, 2010, p. 35).

Spitzer emphasized that Vilenkin's statement should not be taken lightly in that he asserted that their equations are valid and apply practically independently of the laws of physics that could be found in any imagined universe, and moreover, and also that such a universe with no beginning is impossible.

The extensive general applicability of the BGV Theorem is such that it establishes a past-time boundary in a diversity of models, including eternal inflation scenarios (i.e., "bubble universe" or "bouncing universe" models), as well as, cyclic evolution scenarios

(Spitzer, 2010). Craig and Sinclair (2009) describe the reasons why even the static seed scenario or "emergent universe" cannot escape the BVG Theorem:

> [The asymptotically static hypothesis] has the dilemma that it must begin static and then transition to an expansion. Hence, the static phase is metastable, which implies that it is finite in lifetime. The universe begins to exist (as cited in Spitzer, 2010, p. 38).

Even prior to the development of the BGV Theorem, in 1998, Stephen Hawking affirmed the invalidity of the static or steady state model: "…the discovery of the microwave radiation by Penzias and Wilson in 1965 also indicated that the universe must have been much denser in the past. The steady state theory therefore had to be abandoned" (Hawking, 1998, p. 63).

The BGV Theorem has exacerbated some cosmologists who still seek an acceptable alternative model that avoids an absolute beginning and the BGV Theorem's impact:

> Many people do not like the idea that time has a beginning, probably because it smacks of divine intervention. (The Catholic Church, on the other hand, seized on the big bang model and in 1951 officially pronounced it to be in accordance with the Bible.) There were therefore a number of attempts to avoid the conclusion that there had been a Big Bang (Hawking, 1998, p. 62).

Hawking's mention of the Catholic Church in 1951 is in reference to an encyclical by Pope Pius XII, entitled, *The Proofs For The Existence of God in the Light of Modern Natural Science*, wherein he gave a scholarly account of the recognized conclusions of several scientific disciplines concerning the origins of the Earth and cosmos (Papal Encyclical, 1951). The encyclical does not, as Hawking proposed, constitute an official Church position on the validity of Big Bang theory, but the pope did comment on its rationality and consistency.

Alexander Vilenkin (2007), of Tufts University in Boston, remarked on the inescapable consequences for cosmologists, at least at present, of the BGV Theorem:

> It is said that an argument is what convinces reasonable men and a proof is what it takes to convince even an unreasonable man. With the proof now in place, cosmologists can no longer hide behind the possibility of a past-eternal universe. There is no escape: they have to face the problem of a cosmic beginning (p. 176).

A meeting of scientists, entitled, 'State of the Universe' was held in January of 2012 at Cambridge University, in honor of Stephen Hawking's seventieth birthday (Magis Video, 2012). During the conference, Alexander Vilenkin, discussed each of the known possible alternate candidate scenarios to the Big Bang theory, which include: (1) eternal inflation scenarios; (2) cyclic evolution; and (3) static seed or "emergent universe" models. Vilenkin's presentation demonstrated how the BGV Theorem establishes that each of these models, as well as any derivative of them, by necessity, must have a singularity or absolute beginning (Magis Video, 2012).

Vilenkin's concluded his presentation at Cambridge by once again restating the unavoidable consequence of the BGV Theorem: "All the evidence we have says that the universe had a beginning" (Magis Video, 2012).

Momentous progress within theoretical physics over the last century, including Einstein's *General Relativity* and the 1929 discovery of Hubble expansion, led to the development of Lemaitre's Big Bang theory (Spitzer, 2010). Lemaitre's Big Bang theory was ultimately confirmed by Penzias and Wilson in 1965 with their discovery of cosmic microwave background radiation (CBR) (Hawking, 1998). As a result of these developments, the great majority of cosmologists have since abandoned Newton's eternal universe hypothesis in favor of the Big Bang theory, which postulates a singularity or absolute beginning approximately 13.7 billion years ago. The BGV Theorem, developed in 2003, then proved the mathematical necessity of the singularity of any inflationary universe, which is, for the vast majority of theoretical physicists, the final confirmation of the Big Bang model and an absolute beginning of space and time approximately 13.7 billion years ago (Spitzer, 2010).

Significant Big Bang Discovery in 2014

In 1979, theoretical physicist and cosmologist, Alan Guth, first proposed that in the instant immediately following the Big Bang event, the universe experienced an extremely rapid, massive, and exponential expansion (Overbye, 2014). If substantiated, the immediate and violent expansion predicted by Guth would account for several unexplained phenomena, such as, the uniformity of the heavens. Guth's hypothesis, simply termed "inflation", guided cosmology for more than three decades, but Guth wondered if it could ever be empirically confirmed.

The 1965 discovery of cosmic microwave background radiation (CBR) (i.e., the light from the Big Bang explosion) had been enough to convince the overwhelming majority of cosmologists of the truth of the Big Bang event (Hawking, 1998; Spitzer, 2010). But then in March of 2014, astronomers at the South Pole used telescopes capable of observing CBR and made an astonishing discovery. The team of astronomers observed ripples in the fabric of space-time, as Einstein had envisaged. These ripples in space-time are primordial undulations that broadcast across the universe at the speed of light, which were caused as the universe was wretched apart when it was approximately one trillionth of a trillionth of a trillionth of a second old (Overbye, 2014).

Einstein had predicted the existence of gravitational waves (Klotz & Begley, 2014). Fr. Lemaitre had united Einstein's *Theory of General Relativity* and Hubble's observation of the expanding galaxies to formulate his Big Bang theory (Spitzer, 2010). Computer models had predicted the size and shape of the CBR waves. The team of astronomers stationed at the South Pole confirmed that Einstein, Lemaitre, and Guth were correct. Harvard University physicist, Avi Loeb, announced: "These results are not only a smoking gun for inflation, they also tell us when inflation took place and how powerful the process was" (Klotz & Begley, 2014, para. 11). The gravitational waves present in the CBR are consistent with measurements that place the Big Bang event approximately 13.7 billion years ago (Spitzer, 2010).

Guth of Massachusetts Institute of Technology (MIT) described himself as, "bowled over," as he had not expected such a definitive confirmation of his theory in his lifetime (Overbye, 2014, para. 16). The discovery of these primordial waves undulating across the cosmos are the once illusive, but now detected and observed, "smoking gun" of the Big Bang and Inflation Theories. A colleague of Guth's at MIT, proclaimed that this discovery of gravitational waves present in the CBR will be recognized as one of the greatest scientific discoveries of all time (Overbye, 2014).

Thus, within the context of their discipline, modern physicists have made discoveries that, unless reversed by an extremely improbable and unforeseeable development, have empirically confirmed an absolute beginning to the universe by means of the Big Bang event (Hawking, 1998; O'Connor & Robertson, 2008; Overbye, 2014; Vilenkin, 2007). Moreover, the BVG Theorem mathematically confirms that this universe and all possible universes with a Hubble expansion greater than zero, by necessity, must have had a beginning (Spitzer, 2010). These discoveries are significant because whether or not the universe began at a singular point in time represents another intersection of faith and science, as it is of interest to both scientists and theologians. It is ironic that the creationist versus Darwinist argument hinges, at least in part, on the origins and age of the universe, and significantly, the creationists belief in a very young universe (i.e., less than 10,000 years old) has been refuted by the discovery and confirmation of the Big Bang event (Skehan & Nelson, 2000).

In recent decades, however, theoretical physicists have embarked on yet another path of discovery that also has profound implications for the relationship of faith and science. As physicists, cosmologists, and mathematicians came to comprehend the extreme improbability of an anthropic universe (i.e., a universe possessing enough intrinsic orderliness to sustain any form of life whatsoever), the improbability that this universe randomly evolved into a life-sustaining configuration became difficult for many to accept (Flew & Varghese, 2007; Spitzer, 2010).

Universal Constants and Anthropic Conditions

Aristotle, Aquinas, William Paley, and many others, advanced the teleological argument (i.e., argument from design) in light of the apparent orderliness and symmetry of nature (Spitzer, 2010). Later, during the Age of Enlightenment, the teleological argument garnered serious criticism – even scorn – from intellectuals who had accepted Newton's proposition that the universe is eternal, and thus, virtually any combination of phenomena are conceivable. But then, by the mid-20th century, evidence had begun to accumulate that suggested the finite nature of the universe in both mass and time, which led some to question the probability that anthropic conditions could arise through mere chance (Flew & Varghese, 2007; Spitzer, 2010).

Even before the development of the Big Bang theory, Albert Einstein perceived the extreme improbability of an anthropic universe capable of sustaining life (Hyper Physics, n.d.). In a letter to a friend, published within *Lettres à Maurice Solovine*, Einstein reasoned as follows:

> You find it strange that I consider the comprehensibility of the world to the degree that we may speak of such comprehensibility as a miracle or an eternal mystery. Well, a priori one should expect a chaotic world which cannot be in any way grasped through thought. . . .The kind of order created, for example, by Newton's theory of gravity is of quite a different kind. Even if the axioms of the theory are posited by a human being, the success of such an enterprise presupposes an order in the objective world of a high degree which one has no a-priori right to expect.

That is the "miracle" which grows increasingly persuasive with the increasing development of knowledge (as cited in Hyper Physics, n.d., para. 4).

Since that time, extraordinary developments in astrophysics have substantiated the finite parameters of the universe, which has enabled physicists to mathematically calculate the incredible odds against every one of the several universal constants falling in the range of anthropic conditions (Flew & Varghese, 2007; Spitzer, 2010). Now, rather than an infinite number of "tries" to arrive at virtually any degree of complexity, Big Bang cosmology has fundamentally changed the state of cosmology, by radically limiting the number of "tries" to a very finite number. "This comparatively small number of 'total possible mass energy interactions in the universe for all time' revealed the extreme improbability of high degrees of complexity arising out of the universe by pure chance" (Spitzer, 2010, p. 49).

The equations of physics derive from a variety of interactions and interrelationships of universal constants that comprise the structure of the universe (Spitzer, 2010). If the values of the constants coalesce in a precise order, they could give rise to complex – even highly complex – structures, such as life forms. In actuality, though, the extreme likelihood is that these constants would coalesce to form non-anthropic conditions that could never give rise to complex structures, including life forms. Remarkably, however, against astronomical odds, the universal constants coalesced in such a way as to give rise to life (p. 56-57).

Several scientists, including Roger Penrose, Owen Gingerich, Fred Hoyle, Walter Bradley, Brandon Carter, Paul Davies, and others, have assembled an immense amount of data that reveals the extremely narrow anthropic range the universal constants fell within (Spitzer, 2010). It is the case that this extremely limited range for each of the universal constants is necessary for both an initial state and gradual unfolding or evolution of the universe toward anthropic conditions. Physicists have identified the odds that several universal constants would fall into the anthropic range necessary to support life, but the following seven will suffice to demonstrate the precision that makes up the structure of the universe.

(1) The first instance concerns Roger Penrose's (1989) discovery of the extreme improbability of a low-entropy condition (that is essential for an anthropic universe) occurring within the universe. Spitzer (2010) noted the extreme improbability of low entropy appearing:

> The odds of our anthropic universe arising amidst the total phase-space volume of possible universes for a creation event is so exceedingly, exceedingly, exceedingly remote that its notation in regular exponential form is one part in: $10^{10000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000}$. This number is so large that if we were to write it out in ordinary notation (with every zero being, say, ten point type), it would fill up a large portion of the universe (p. 59).

(2) In the second instance, the theoretical physicist Paul Davies (1982), calculated the interrelationship among the gravitational constant, weak force constant, and the cosmological constant (Λ), as they relate to the rate of acceleration or potential collapse of the universe (Spitzer, 2010). Davies explained:

> If Λ were several orders of magnitude greater, the expansion of the universe would be explosive, and it is doubtful if galaxies could ever have formed against such a disruptive force. If Λ were negative, the explosion would be replaced by a catastrophic collapse of the universe. It is truly extraordinary that such dramatic effects would result from changes in the strength of either gravity, or the weak force, of less than one part in 10^{40} (Davies, 1982, p. 108).

If the interrelationship of the gravitational constant, weak force constant, and cosmological constant in the universe had been even slightly different, then the universe would have either: (a) expanded at such an incredible rate that no matter could formed into clusters or (b) experienced a catastrophic collapse (Davis, 1982). The formation of life would have been impossible in either case (Flew & Varghese, 2007; Spitzer, 2010).

(3) The third instance relates to the immense improbability that the strong force constant, particularly the relationship of the strong force constant to the electromagnetic constant, would produce anthropic conditions (Spitzer, 2010). For anthropic conditions to exist, the strong force constant cannot vary more than 2% from its present value. If the strong force constant varied more than 2%, hydrogen and any other element heavier than hydrogen could never have formed. A variance of more than 2% would have negated the possibility of any life form (Flew & Varghese, 2007; Spitzer, 2010). A reduction of only 2 percent in the strong force and its associated constant would prohibit the formation of any nuclei containing large numbers of protons, thus eliminating the formation of any elements heavier than hydrogen. Conversely, if the strong force and its associated constant were only 2 percent greater, then all hydrogen in the universe would have been

converted to helium and heavier elements. Thus, a 2 percent increase would have produced a universe devoid of any water, as well as any long-term fuel source for the stars. The point is that the absolute value of the strong force constant and its value related to the electromagnetic force constant, as critical to life as they are, astonishingly, but apparently randomly, are found to be in a life-supporting range (Spitzer, 2010).

(4) The fourth instance concerns the improbability that the relationship between the: (a) gravitational and weak force constants: and (b) the neutron-proton mass and electron mass would coalesce within the anthropic range (Spitzer, 2010).

Davies (1982) discovered an "extraordinary coincidence" in the relations between mass and energy in a nuclear reaction (as cited in Spitzer, 2010, p. 61). If the relationship between the mass and energy in a nuclear reaction had varied slightly in either direction, either hydrogen would have never developed within the universe or diverse heavier elements would have been significantly limited (Spitzer, 2010).

(5) The fifth instance concerns the relationship of the gravitational constant to the electromagnetic constant and the ratio of electron to proton mass, which, again, fall within a minute anthropic range (Spitzer, 2010). The formation of sufficiently stable stars would have been precluded had these values varied even slightly in either direction.

Davies (1982) commented on the incredibly small variance that is permissible in the interrelationship of the gravity constant, electromagnetism constant, and "electron mass relative to proton mass," which, had they been slightly different, only red dwarfs or blue giant stars would have developed and both are incapable of supporting life (p. 71). Davies noted how astonishing this coincidence is:

> Putting in the numbers, one obtains 5.9×10^{-39} for the left hand, and 2.0×10^{-39} for the right hand side. Nature has evidently picked the values of the fundamental constants in such a way that typical stars lie very close indeed to the boundary of convective instability. The fact that the two sides of the inequality are such enormous numbers, and yet lie so close to one another [10^{-39}], is truly astonishing. If gravity were very slightly weaker, or electromagnetism very slightly stronger, (or the electron slightly less massive relative to the proton), all stars would be red dwarfs. A correspondingly tiny change the other way, and they would all be blue giants (Davies, 1982, p. 72-73).

(6) The sixth instance relates to the relationship of the weak force constant to the carbon atom (Spitzer, 2010). Once again, in order for the carbon atom (i.e., the building block of life) to exist, the relationship between the weak force constant and the carbon atom must fall within a range very similar to that which currently exists. Davies (1982) noted that even a slight variation in the value representing the relationship would have prevented the development of supernovae, which provide the heat necessary to produce carbon atoms:

> We owe the presence of the carbon in our bodies, the iron core of our planet and the uranium in our nuclear reactors to supernovae that occurred before the solar system formed. Without supernovae, Earth-like planets would not exist.
>
> If the weak interaction were much weaker, the neutrinos would not be able to exert enough pressure on the outer envelope of the star to cause the supernova explosion. On the other hand, if it were much stronger, the neutrinos would be

trapped inside the core, and rendered impotent. Either way, the chemical organization of the universe would be very different (Davies, 1982, p. 68).

(7) The seventh instance can be offered from the resonances of atomic nuclei (Spitzer, 2010). "These resonances are dependent upon the precise values of fundamental constants as well as the generation of atomic nuclei through universal and stellar evolution," which are a prerequisite to the production of carbon and carbon-based life forms (p. 64). Astronomer Owen Gingerich (2000) provided the following explanation:

> . . . here the internal details of the carbon nucleus become interesting: it turns out that there is precisely the right resonance within the carbon to help this process along. . . . The specific resonances within atomic nuclei are something like [a sound wave which can shatter a glass at a very precise frequency], except in this case the particular energy enables the parts to stick together rather than to fly apart. In the carbon atom, the resonance just happens to match the combined energy of the beryllium atom and a colliding helium nucleus. Without it, there would be relatively few carbon atoms. Similarly, the internal details of the oxygen nucleus play a critical role. Oxygen can be formed by combining helium and carbon nuclei, but the corresponding resonance level in the oxygen nucleus is half a percent too low for the combination to stay together easily. Had the resonance level in the carbon been 4 percent lower, there would be essentially no carbon. Had that level in the oxygen been only half a percent higher, virtually all of the carbon would have been converted to oxygen. Without that carbon abundance, none of us would be here now (pp. 524-525).

Just how improbable it is that the precise resonance of carbon nucleus coinciding perfectly with the resonance of beryllium, helium, and oxygen can be adduced from the fact that the English astronomer and mathematician, Fred Hoyle (1983), was moved from atheism to a belief in a "supercalculating Intellect" after discovering this phenomenon (as cited in Spitzer, 2010, p. 64).

The odds against the universal constants, which control the interrelationship among space, time, and energy in the universe, falling into the precise, narrow life supporting range, comparable to the virtual open range of possibilities of non-life supporting values, are astronomically minuscule (Spitzer, 2010). Put another way, against all conceivable odds, following the Big Bang event the universal constants fell within a life supporting range, even though "the possible values that these universal constants could have had that would have disallowed any life form from developing are astronomically higher (falling within a virtually open range) (p. 50). Thus, the result is that the odds are astronomically high "against an anthropic condition occurring, making any life form (or universal condition allowing a life form) exceedingly improbable" (p. 50).

The human race has basically taken the existence of anthropic conditions (i.e., life enabling conditions) for granted, until physicists in the 20th century, such as Albert Einstein, began to seriously consider the extreme improbability that the universe would possess anthropic conditions at all (Hyper Physics, n.d.). Complex mathematical calculations have since been performed that demonstrate the incredible odds of this universe possessing even one life-enabling universal constant and the odds of every universal constant existing in the anthropic, life-enabling range is exponentially less likely. That is, the idea that this universe possesses anthropic conditions by mere chance has been shown to be far too implausible for serious physicists to accept. Thus, the overwhelming consensus among physicists is that the Big Bang event that occurred approximately 13.7 billion years ago, has supplanted Newton's conception of an eternal universe (Flew & Varghese, 2007; Hess & Allen, 2008; Jaki, 1990; Skehan & Nelson, 2000; Royal, 2006; Spitzer, 2010).

These 20th and 21st century developments in physics and astrophysics have confirmed the finite nature of the universe's total mass and time of existence and have tremendous implications for the theory of evolution, as well (Spitzer, 2010). The idea that an inexhaustible timeline could potentially give rise to any combination of events lent tremendous weight to biological evolutionary theory. Now, however, the discipline of physics has put a limit on the time available for the evolution of life forms to have developed (Flew & Varghese, 2007). The theory of evolution continues, of course, to be explored within a variety of scientific disciplines and one of the most significant of these disciplines, in terms of evolution, is molecular biology.

Evolutionary Theory and Biology

Biological evolution is of paramount importance within the context of this dissertation, as it is directly related to the second subquestion herein, which concerns exploring the origins and progress of science in light of the controversy surrounding the long-standing creationist versus Darwinist debate within United States public schools. The remainder of this chapter is dedicated to exploring the various aspects of this ongoing controversy, in an effort to assist educators as they attempt to make sense of this important and sometimes very complex issue.

The discipline of molecular biology began following the 1953 discovery of the double-helix structure of deoxyribonucleic acid (DNA), which holds hereditary material and to date, provides the strongest evidence of the evolution of living organisms (Ayala, 2010). DNA is so important to the study of biology that it has been called the "chemical of life" (as cited in Ayala, 2010, Why is Evolution a Theory section, para. 21). Biological evolution seeks to explain three basic features of biological life: (1) similarities of living organisms; (2) diversity of life forms; and (3) adaptations of living organisms. In the mid-20th century, biologists began to increasingly understand their discipline though the evolutionary framework. For modern biologists, evolution is the central organizing principle of their discipline. The prominent evolutionist, Theodosius Dobzhansky, contended that "nothing in biology makes sense except in the light of evolution' (as cited in Ayala, 2010, Why is Evolution a Theory section, para. 13).

Most biologists maintain that DNA contains the genetic information for the three most fundamental aspects of life: "(1) all living processes in organisms, (2) the precision of biological heredity, and (3) biological evolution" (Ayala, 2010, What is DNA section, para. 1). DNA contains the genetic information that controls all life processes. Scientists have determined that the amount of genetic information contained within DNA is enormous because the length of each DNA molecule is enormous. For example, when the human genome is coded it is 3 billion letters long, as it reveals the precise DNA that an individual inherits from each parent. The amount of information is so staggering for one human genome and other organisms that scientists electronically store the information in computers, rather than print the information, which would fill a thousand books of a thousand pages each (Ayala, 2010).

DNA also accounts for the extreme intricacy and precision of biological heredity, as well as mutation within living organisms (Ayala, 2010). Although the encoded nucleotide sequence of DNA is faithfully reproduced during replication almost perfectly, occasionally mutations occur during replication. Mutations appear when "daughter cells differ from the parent cells (and from each other) in the nucleotide sequence or in the length of the DNA" (Ayala, 2010, What is DNA section, para. 4). Mutations usually involve a single nucleotide or letter within the code, but on occasion mutations can encompass several letters, and, significantly, the newly changed DNA is passed on to all cells that are descended from the first (Ayala, 2010; Behe, 2007).

In terms of evolution, the significant mutations are those that occur in the eggs and sperm cells or the cells from which the egg and sperm cells are derived because these are the cells that produce succeeding generation (Ayala, 2010). Other mutations that occur in other cells are generally insignificant. Mutations can give rise to diseases and other abnormalities, such as in the case of a person with two different color eyes, but those types of abnormalities are the exception because mutations themselves are rare (Ayala, 2010; Behe, 2007; Schuster, 2008).

Mutation rates, particularly for mutants that exhibit conspicuous effects, such as those that cause disease and abnormalities, have been measured in a large variety of organisms (Ayala, 2010). "In humans and other animals, rates of mutation typically range between one mutation for every 100,000 cells and one mutation for every million cells" (What is DNA section, para. 7). Thus, although mutation rates are very low, new mutations occur within every generation of every species, simply because each species is comprised of so many individuals and each individual possesses so many genes. The human population currently exceeds 6 billion people worldwide and if any given mutation occurs once in every million people, the human population would be carrying and passing down six thousand newly arisen mutations (Ayala, 2010).

Biologists maintain that mutations passed down through DNA make evolution possible and DNA has revealed the mechanism through which evolution occurs (Ayala, 2010; Behe, 2007; Schuster, 2008). However, because most often mutations cause defects or diseases as they disrupt the established DNA sequence, if genetic mutations occurred more frequently, the result would be multiple defects within organisms and total disorganization. Within natural selection each DNA sequence has been selected over thousands of generations because of its facilitation of survival and reproduction of the organism in its specific environment. Moreover, mutations provide each generation with new genetic variations, which when constructive and are not harmful to survival, are passed down to succeeding generations. The result is that each species consists of individuals that differ from one another due to numerous genetic mutations (Ayala, 2010).

Biologists have confirmed that although many individuals within a species suffer harm when new environmental challenges arise, the species as a whole will often adapt and survive (Ayala, 2010). For example, where spraying has been concentrated, more than one hundred species of insects have developed resistance to the pesticide dichlorodiphenyltrichloroethane (DDT). These insects, in the history of their species, had never, of course, been exposed to this or any other synthetic compound. Still, pre-existing mutations present in some individuals within the species enabled them to withstand the presence of DDT. That is, they didn't adapt the mutation in one generation because of the presence of DDT, but rather, some members were already resistant, due to genetic mutations they already possessed when they encountered DDT. Insects that did not possess the "adaptation" died and the mutation that enabled survival for the rest was successfully passed down and multiplied through natural selection (What is DNA section, para. 8). The same biological process explains why some parasites and disease-causing bacteria are found to be resistant to antibiotics and other drugs and why many, but not all people in medieval Europe died from the plague.

As scientists sequence human DNA and find mutations that are helpful against natural enemies, they are not simply studying the DNA of an individual, but are actually scrutinizing the results of a millennia long struggle, involving millions, upon millions of people (Behe, 2007). Modern human beings are, in effect, the beneficiaries of helpful mutations sustained by ancestors. Human ancestors who did not sustain helpful mutations were not able to survive against particular threats to survival. The sequencing of an organism’s genome unfolds evidence of evolution that is simply not attainable by way of any other method of inquiry (Schuster, 2008).

The most commonly accepted explanation of the mechanism that accounts for the evolutionary process is Darwin’s theory of evolution (Ayala, 2010; Schuster, 2008; Stark, 2003; Wiker, 2009). Darwinism should be considered in light of its three distinct elements: (1) natural selection; (2) common descent; and (3) random mutation (Behe, 2007). Darwin's assertion that all living organisms can trace their ancestors back to a common ancestor (i.e., common descent) has since been corroborated through DNA evidence. However, common descent itself does not account for the vast dissimilarities between species. Darwin, of course, recognized the incredible variety of living organisms and hypothesized that random mutation paired with natural selection accounts for the extraordinary diversity of species (Behe, 2007).

Natural selection proposes that the most fit members of a species – those best fit or adapted to their environment – tend to survive (Behe, 2007). Schonborn (2008) noted that other experts have challenged the validity of the concept of survival of the fittest by noting the contradiction between that concept and the conclusion reached by other independent scientific disciplines, which speculate that an asteroid hit the earth and annihilated ninety percent of all existing life forms of the time. So, the dinosaurs met their demise as a result of a natural catastrophe – not because of their failure to adapt per se. Thus, the concept of survival of the fittest has been challenged, due to the recognition that in many cases survival depends a great deal upon contingency, apart from adaptability.

Most contemporary biologists maintain that the most significant element of Darwin's theory is the role of random mutation (Behe, 2007). Darwin maintained that the means by which a plant or animal becomes more fit for survival than its relatives is by sustaining one or more fortuitous mutations, which increase its ability to adapt. If the mutation is favorable to survival, then natural selection can take place and the organism's offspring will benefit from that mutation (Schuster, 2008). Thus, natural selection can only take place after a favorable random mutation has been sustained (Behe, 2007).

In terms of the three elements of Darwin's theory of evolution, it is clear that through DNA analysis, molecular biology has uncovered extremely convincing evidence for common descent (Ayala, 2010; Behe, 2007; Schuster, 2008). That random mutation coupled with natural selection can modify living organisms in important ways has been very well substantiated as well. Some, however, have questioned the extent to which Darwin's evolutionary mechanism (i.e., natural selection coupled with random mutation) can account for the great variety of species on Earth (Behe, 2007; Schonborn, 2008; Stark, 2003).

Common Ancestry and DNA

A critical aspect of Charles Darwin's evolutionary theory that is also directly related to the second subquestion herein in relation to the creationist versus Darwinist conflict, is his assertion that all living beings evolved from a primordial life form (Ayala, 2010; Schuster, 2008). Until the second half of the 19th century, the sole means by which to study the connectedness of life forms was through morphology or appearance, which is still in use within paleontology. Subsequent to Darwin, use of the conventional microscope engendered the discipline of cellular biology, which conclusively demonstrated that all living things are comprised of cells. The presence of DNA has, for the first time, enabled biologists to compare the genetic codes of various living organisms and provided molecular biologists with the ability to determine the degree of relationship between living organisms and reconstruct their phylogeny (Schuster, 2008, The Genealogical Tree of Life section, para. 3).

In relation to the genealogical tree of life, molecular biology demonstrates evolution in two ways:

> …first, by showing the unity of life in the nature of DNA and the workings of organisms at the level of enzymes and other protein molecules; second, and most important for evolutionists, by making it possible to reconstruct evolutionary relationships that were previously unknown, and to confirm, refine, and time all evolutionary relationships from the universal common ancestor up to all living organisms. The precision with which these events can be reconstructed is one reason why the evidence from molecular biology is so useful to evolutionists and so compelling (Ayala, 2007, Molecular Biology section, para. 2).

Human DNA, and, in fact, the DNA molecules of all living organisms have undergone a vast number of individual mutations, which through time has altered the primordial DNA sequence (Ayala, 2007). All living organisms in existence today necessarily carry within their DNA a “memory” of their past and molecular biologists are able to draw very accurate connections between various organisms, based on this stored “memory” (Schuster, 2008, The Genealogical Tree of Life section, para. 3). Molecular biology provides the most convincing evidence for evolution by way of the persuasive evidence that the phylogenetic tree, based in both morphology (i.e., the study of the form and structure of life forms) and DNA evidence, with some exceptions, agree down to the most exacting details (Ayala, 2010, Behe, 2007; Schuster, 2008). Thus, both morphology and DNA evidence independently substantiate a discernible tree of life and both disciplines are in accord in their conclusions, so together represent the foundation of biology, as it relates to the study of the evolutionary cycle (Schuster, 2008).

Understanding precisely how DNA substantiates common ancestry is crucial to any discussion related to DNA's place in evolution (Schuster, 2008). DNA offers the most convincing evidence that one aspect of Darwin's theory – common descent – is correct (Behe, 2007). In June of 2000, the announcement was made that a milestone in scientific achievement had been achieved: the sequencing of the human genome had been completed. Since then, the genomes of hundreds of other organisms have been sequenced and although most are single cell microbes, the genomes of some larger plants and animals have also been sequenced, such as, chimps, dogs, and zebrafish. The sheer scope of the DNA data has allowed scientists to explore the many different ways DNA can change. Essentially, the ability to examine the kinds of variations or mutations that can arise in DNA has only been recognized in the last few decades. DNA offers a chronological record of both significant and insignificant mutations that various species have sustained during their time on earth (Behe, 2007; Schuster, 2008).

Although DNA is similar to a blueprint, it is not exactly a blueprint (Ayala, 2010). Accordingly, only a very small fraction of the DNA sequence is directly involved in creating proteins and building life. Scientists are generally convinced that most of the sequence or code is excess DNA, where mutations can arise innocuously (Behe, 2007).

There are, in fact, several different types of mutations present in the DNA sequence (Behe, 2007; Schuster, 2008). For example, a substitution mutation occurs when one single letter of the billions in the DNA sequence is substituted for another letter. A deletion mutation occurs when a portion of DNA, which can range from a single letter to a large portion of the genome, is accidentally left out during DNA duplication. An insertion mutation occurs when extra DNA is accidentally placed into a region, and can, like deletion mutations, range from one single letter to a large portion of the DNA sequence. Gene duplication is another type of mutation and offers evolution a great opportunity because now one copy of the gene can perform the work it was originally intended for, while a second copy is free to be used in a difference capacity. An inversion mutation occurs when some of the normal structure of the cell goes slightly astray, such as when a section of (Behe, 2007):

> …the DNA double helix can be cut out, flipped over, and switched back in. This sort of mutation is thought to help divide one species into two species. Organisms with inverted regions in their DNA can mate with each other, but they often cannot mate as successfully with their 'unflipped' cousins. One species of mosquito that carries malaria in west Africa seems to be dividing into several separate species because of large genomic inversions (p. 67).

Although scientists have identified the several types of mutations present in DNA, it has also become clear that negative mutations appear hundreds of times faster than beneficial mutations (Ayala, 2010; Behe, 2007).

Centuries ago, scientists noted the remarkable anatomical similarities between humans and various primate species (Behe, 2007; Schuster, 2008). But with the discovery of DNA, scientists have now compared the sequences of proteins and DNA for both humans and primates. DNA enables scientists to determine who is related to who, establish paternity, and ascertain which side of the family a genetic disease exists within. The significance of DNA, however, goes deeper because it can not only infer relationships among modern humans, but among ancients as well. Thus, for example, scientists have been able to identify with reasonable accuracy when particular diseases, such as sickle cell anemia, first arose in human history (Behe, 2007).

Likewise, in the 1980s, through comparisons of DNA data from present day humans, scientists hypothesized the existence of "Mitochondrial Eve," which submits that all modern human beings are descendants of a single woman who lived approximately 200,000 years ago (Behe, 2007). The plausibility of “Mitochondrial Eve” was revisited in 2010 by a team of Rice University researchers, who conducted the most complete statistical examination of the human species’ genetic links to "Mitochondrial Eve” (Cyran & Kimmel, 2010). The researchers performed a side-by-side comparison of ten independent human genetic models, wherein each made use of a very different set of assumptions pertaining to when humans first lived, migration, expanded, and dispersed throughout the Earth. The researchers concluded that the maternal ancestor of every living human being lived approximately 200,000 years ago in Africa.

The first DNA sequences were deciphered early in the 1960s and scientists were shocked because they expected the biological molecules of different organisms to be utterly different, but they were remarkably similar in very important ways (Behe, 2007). For example, one of the first proteins to be sequenced from a wide range of living organisms was hemoglobin and the DNA served to substantiate the correctness of the biological classification system that had been established centuries earlier. Researchers discovered:

> …the amino acid sequence of the beta chain of human hemoglobin was much different from that of a fish, somewhat different from that of a kangaroo (a marsupial mammal), pretty similar to that of a dog (a placental mammal), and *identical* to that of a chimpanzee (p. 69).

Darwin's image of a tree of life branching in different directions (i.e., common descent) was substantiated by the protein pattern within the DNA sequencing of a wide range of living organisms (Behe, 2007). The molecular similarities, however, were not only found to be present within hemoglobin, but several other molecular similarities were found to be existing between humans and other primates, and significantly, underlying all forms of life (Ayala, 2010; Behe, 2007; Schuster, 2008).

Behe (2007) observed that a serious objection could be raised, which would purport that different animals all possess similar "hemoglobin because that's the only protein that could really work to carry oxygen efficiently" (p. 70). In the same way, for instance, that carbon is the basis of all living organisms because it is versatile enough to support life forms. In short, the objection could reason that perhaps all animals possess similarities in their molecular machinery and hemoglobin is one of those essential elements.

That objection, however, is not sensible in the case of a shared feature between two different organisms, which has no functional role to play in sustaining life (Behe, 2007). Accordingly, when two lineages both possess an arbitrary genetic accident, the case for common dissent becomes extremely convincing. Just as the case for plagiarism becomes overwhelming when two writers misspell unusual words within the same work, the same exact DNA abnormality or abnormalities found within two distinct species is compelling evidence for common ancestry and "that sort of evidence is seen in the genomes of humans and chimpanzees" (p. 70). For example, an example of evidence of common ancestry between humans and chimpanzees is the presence of a broken copy of a gene, which in other mammals assists in internally producing vitamin C, which is present in both humans and chimps. Neither humans nor champs, of course, are capable of producing vitamin C internally. The existence of this same abnormality found in the DNA of both humans and chimps, can logically be explained by the existence of a common ancestor to both species, which then passed the DNA abnormality on to both humans and chimps (Behe, 2007).

More compelling evidence for common ancestry among humans and primates is present in a broken or abnormal hemoglobin gene (Behe, 2007). The human genome contains five genes for proteins that come into play at specific stages of development from embryo through adulthood. The chimpanzee genome possesses the same exact genes in the same exact order. "…human DNA contains a broken gene (called a 'pseudogene') that closely resembles a working gene for a beta chain, but has features in its sequence that preclude it from coding successfully for protein" (p. 71). Chimpanzee DNA, again, has a very similar pseudogene at precisely the same position in the astonishingly lengthy sequence. The beginning of the human pseudogene has two specific changes in just two nucleotide letters, which seem to effectively deactivate the gene. The chimpanzee pseudogene at precisely the same position in the sequence possesses the same exact changes in the nucleotide letters. Moreover, a deletion mutation with one particular letter missing is present further down in the human pseudogene, which irrevocably disorders the genes coding. Remarkably:

> The very same letter is missing in the chimp gene. Toward the end of the human pseudogene another letter is missing. The chimp pseudogene is missing it, too. The same mistake in the same gene in the same positions of both humans and chimp DNA… It's hard to imagine how there could be stronger evidence for common ancestry of chimps and humans (p. 71).

The vast majority of biologists and molecular biologists are in agreement that DNA evidence has effectively confirmed Darwin's claim of common descent, which purports that all living organisms on earth are biological relatives (Ayala, 2010; Behe, 2007; Schuster, 2008).

Still, common ancestry is only one element of Darwin’s theory and evolution itself does not stand or fall on Darwin’s proposed evolutionary mechanism (Muckermann, 1909). An alternative evolutionary mechanism may be found, apart from random mutation coupled with natural selection, which more precisely explains evolutionary development and the incredible diversity of life forms on earth. Many experts, including Neo-Darwinists, argue that in the absence of perceptible incremental steps, Darwin’s proposed mechanism seems incapable of accounting for the great diversity of life forms (Depew & Weber, 2011). Thus, some Neo-Darwinists are actively searching for another potential mechanism that can account for the absence of evidence of small, incremental changes producing numerous transitional forms in the development of species (Goldschmidt, 1940; Gould, 1977), which Darwin’s evolutionary mechanism is dependent on (Darwin, 1964).

The Theory of Evolution vs. Darwinism

Some contemporary scholars have noted that to be critical of any element of Darwin’s theory of evolution is tantamount to academic heresy and equated to being anti-evolution (Stark, 2003). Even contemporary Darwinists have been deemed to be evolutionary heretics after admitting any discrepancies within Darwin’s theory (Dennett, 1996; Gould, 1980). Nonetheless, a critical aspect of this dissertation requires an honest exploration of the nature of the now century and a half long creationist versus Darwinist controversy, which is having a measurable, deleterious effect on science education in United States public schools. Modern research has illuminated some old and uncovered some new problems related to Darwin’s theory. Analysis of the strengths and weaknesses of Darwin’s evolutionary theory in light of the implications for science education within United States public schools is provided below.

There is a notable disagreement among experts that does not concern whether or not evolution occurs in nature, but to what extent Charles Darwin’s proposed evolutionary mechanism (i.e., natural selection coupled with random mutation) can account for the complexity and diversity of earthly life forms (Depew & Weber, 2011). That is, some evolutionists question whether or not Darwin’s theory can account for the diversity of living organism or if another evolutionary model, postulating an alternative evolutionary mechanism, could more clearly describe biological history (Depew, 2013).

For example, Depew did not question whether or not the evolution of life forms occurs in nature, but still pondered as to:

> …why, among competing evolutionary frameworks, Darwinism has been more dominant than its rivals, and at the curious fact that when one version of Darwinism gets into empirical trouble it is usually succeeded not by non-Darwinism, but by a new, more explanatorily powerful, empirically less objectionable version of the theory of natural selection (University of Iowa, n.d., para. 3).

The most important objections to Darwinism have been well documented: (1) the missing links (i.e., numerous transitional forms linking the species) have not been found after 150 years of intensive research; (2) the systems-analytical impracticality that a living system (e.g., reptiles) should be remade by innumerable small mutations into another living system (e.g., birds); (3) the problematic character of the concept of the survival of the fittest, in light of scientific finding that survival is often a contingency or matter of luck and not a particular fitness (Schonborn, 2008). For example, “The dinosaurs—and many other species—became extinct because of catastrophes and not on account of their failure to adapt” (p. 85).

Probably the most crucial objection to Darwin’s mechanism, though, concerns the criteria by which to judge his theory, which he offered in his *Origin of Species*: "If it could be demonstrated that any complex organ existed, which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down” and then added, “but I can find out no such case" (Darwin, 1964, p. 189).

Darwin also rejected the notion that a new species could be produced suddenly, because, quite clearly, it ran counter to his theory of natural selection, which would necessitate incremental changes over an immense period of time. Darwin unequivocally concurred with Carolus Linnaeus's 18th century assessment that nature takes no leaps (Stark, 2003). Thus, he concluded: "To admit such a possibility, is, as it seems to me, to enter into the realm of miracle, and to leave those of Science" (Darwin, 1993, p. 316).

Although he is popularly understood to be the originator of the theory of evolution, Charles Darwin was not the first to propose an evolutionary explanation of nature (Wiker, 2009). Several others had proposed and written about evolution long before Darwin's 1859 publication of *On the Origin of Species by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life*. The ancient Greeks had observed fossils and speculated about evolution. For example, in the first-century B.C., the ancient Greek philosopher, Lucretius, proposed an evolutionary theory much like Darwin's. Later, in 1809, Jean Baptiste Lamarck's published his *Philosophie Zoogique* and Lamarck's work was then followed up by his principle defender, Geoffroy de Saint-Hilaire. But undoubtedly, Darwin's primary intellectual influence was his famous grandfather, Erasmus Darwin, who had composed a medical-zoological treatise entitled, *Zoonomia,* which described his own theory of evolution by means of a process he termed "transmutationism" (p. 3).

Thus, the "theory of evolution" and Darwinism are not interchangeable terms, although they are commonly used as such within contemporary literature (Muckermann, 1909). Darwin's revolutionary contribution to the theory of evolution was the mechanism through which he proposed evolution occurs (i.e., through natural selection coupled with random mutation) (Stark, 2003). Based on careful observation of the fossil record, scientists had long since perceived that life forms had apparently progressed in biological complexity over immense periods of geologic time (Ayala, 2010; Stark, 2003; Wiker, 2011). For example, only simple organisms have been observed in the oldest geological strata, whereas more complex organisms have been found in the more recent strata. Thus, for centuries, many had speculated that an evolutionary process had transpired and Darwin entered the conversation in the latter half of the 19th century with his theory of natural selection (Wiker, 2009).

Prior to Darwin, Carolus Linnaeus (1707– 1778), had classified the biological world into nested categories of genus (e.g., mammals, reptiles, etc.), species (dogs, horses, elephants, etc.), and varieties within species (e.g., labrador, terrier, poodle, etc.) (Linnean Society of London, n.d.). Careful empirical observation of the evidence indicates that the divisions between species are definite and firm to the degree that interbreeding is limited to varieties within a particular species, but not possible across species. Empirical science has thus concluded that variations within species are possible and present, but new species cannot be generated through crossbreeding across species (Muckermann, 1909; Stark, 2003).

Nonetheless, great variations within species do exist and Darwin's most important contribution to the theory of evolution (i.e., the principle of natural selection) seeks to account for those variations (Ayala, 2010; Behe, 2007; Schuster, 2008; Stark, 2003; Wiker, 2009). Darwin's principle of natural selection is comprised of three elements: (1)

organisms within species vary slightly in many different ways and those differences are inheritable; (2) all living organisms are in a struggle for survival and the specific traits that are most conducive to survival will be handed down through reproduction; and (3) different ecological and environmental conditions govern survival, and thus, variations between species (i.e., breeds) were the result of differing conditions (Stark, 2003, p. 179).

Darwin (1964) dedicated several years attempting to discover the biological mechanism that could account for the very origin of species, but in the end, reverted back to his theory of natural selection (Stark, 2003). He proposed that through immense periods of time and within a multitude of environmental conditions, natural selection could produce entirely new species. Slight variations that are well adapted to the particular ecological niche, which are also conducive to survival would be passed down generationally, until eventually, over vast periods of time, those slight variations would have produced sufficient changes to the life form, so as to constitute a new species. Thus, Darwin (1964) maintained that the inescapable condition of natural selection is that new species must originate very slowly, from one slight variation to another (Muckermann, 1909). The exceedingly slow progression of species, through the course of geological epochs, is referred to as the principle of gradualism in nature (Ayala, 2007; Ayala, 2010; Stark, 2003).

Darwin specifically rejected the idea that a species could acquire a favorable cluster of adaptations all at once (Darwin, 1964). But the great difficulty Darwin was faced with was the utter and complete lack of evidence within the fossil record indicating gradualism had occurred (Stark, 2003; Wiker, 2009). Perplexed by the lack of evidence in support of gradualism, he questioned:

> Why, if species have descended from other species by fine gradations, do we not everywhere see innumerable transitional forms? Why is not all nature in confusion instead of the species being, as we see them, well defined ? (Darwin, 1993, p. 212).

On another occasion he admitted:

> But I do not pretend that I should ever have suspected how poor a record of the mutations of life, the best preserved geological section presented, had the difficulty of our not discovering innumerable transitional links between the species which appeared at the commencement and close of each formation, pressed so hardly on my theory (London Quarterly Review, 1923/2012, p. 128).

It seemed to Darwin that nature reveals incredible complexity and organization, but should rather expose, at least in some cases, confusion and underdeveloped species (Darwin, 1993). Darwin acknowledged the glaring lack of transitional forms of species within the fossil record and admitted this lack of fossil evidence represented, "the most obvious and serious objection which can be urged against the theory" (p. 406). He sought to explain the lack of fossil evidence by pointing out the fact that only a small portion of the earth's surface had been studied and vowed that as the geological survey continued, evidence in support of natural selection through gradualism would surface. An intensive search for the missing links (i.e., transitional forms of species) soon commenced and has not subsided since (Schonborn, 2008; Stark, 2003).

The complication Darwin and his successors have been attempting to reconcile specifically concerns the fossil record of the Cambrian period, which began about 540 million years ago and endured for approximately 40 million years (University of California Museum of Paleontology, 2011). Life forms present on earth before the Cambrian period were all soft-bodied with no hard parts or structures (Choi, 2012). The Cambrian period mark the point in the history of life on earth when most of the planets modern animal groups first appeared (University of California Museum of Paleontology, 2011). More specifically, the animals seem to emerge suddenly, already fully formed (Gould, 1972; Gould, 1977; Stark, 2003). Current research has narrowed the actual time frame in which the new species appeared to the first13 million years of the Cambrian period (University of California Museum of Paleontology, 2011) and this sudden emergence phenomenon has generally been described as the "Cambrian Explosion" (para. 1).

The committed Darwinist, Richard Dawkins (1996), expressed his bewilderment in regards to the Cambrian evidence:

> In the Cambrian strata of rocks, vintage about 600 million years (evolutionists are now dating the beginning of the Cambrian at about 530 million years), are the oldest in which we find most of the major invertebrate groups. And we find many of them already in an advanced state of evolution, the very first time they appear. It is as though they were just planted there, without any evolutionary history (p. 229).

In light of the fact that the fossil record has grown immensely over the last century and a half, but thus far has failed to produce the missing links or transitional forms within species (Schonborn, 2008; Stark, 2003), many notable Darwinists have begun to openly critique Darwin's proposed evolutionary mechanism (i.e., random mutation coupled with natural selection) (Gould, 1977). For example, paleontologist and noted evolutionary biologist, Steven Stanley, concluded: "The known fossil record…offers no evidence that the gradualistic model can be valid" (as cited in Stark, 2003, p. 180).

Moreover, the evidence against gradualism continues to mount, as more of the fossil record is unearthed (Stark, 2003; Wiker, 2009). A former curator of the American Museum of Natural History observed: "Many of the discontinuities [in the fossil record] tend to be more and more emphasized with increasing collecting" (as cited in Stark, 2003, p. 180). Harvard University professor of paleontology and evolutionary biology, Stephen Jay Gould, noted significant findings within the fossil record that are particularly inconsistent with gradualism. Gould (1972) observed that species within the fossil record not only do not reveal gradual transition, but exhibit stasis (i.e., little or no change through time). He noted that species seem to change very little during their tenure on earth and any observed morphological changes are limited and directionless. Gould also noted that the fossil record indicates that species appear suddenly in any given local area, and significantly, species appear fully formed. As a Darwinist, Gould expressed no desire to undermine the theory of evolution; he simply set out to explain the fossil evidence in evolutionary terms – even Darwinian terms – apart from gradualism (Gould, 1972). Gould and other Neo-Darwinists were not the first scientists to call into question various aspects of Darwin's once revolutionary theory. Although Darwin had many admirers in his day, some of his contemporaries were not convinced by his arguments and explanations and soon began to express what they judged to be problematic aspects of his theory.

Early Challenges to Random Mutation

The creationist versus Darwinist argument related to the second subquestion herein concerns, escalated a few decades after the 1859 publication of Darwin's *Origin of Species*, but Darwin had several critics among his scientific contemporaries. The scientific community of Darwin's era was acutely aware that the fossil evidence did not support his theory that new species evolve gradually (Stark, 2003; Wiker, 2009). However, they nonetheless, seem to have generally accepted his promise that the fossil record would one day support gradualism, as necessitated by his theory. Francois Jules Pictet, a leading European paleontologist in Darwin's day, conveyed the dilemma he and his peers were facing:

> We find ourselves in a singular position. We are presented with a theory which on the one hand seems to be impossible because it is inconsistent with the observed facts, and on the other hand appears to be the best explanation of how organized beings developed in the epochs previous to ours (Tyler, 2012, Chapter 3, Darwin Resurrected section, para. 2).

In spite of any evidence to the contrary, the Darwinian revolution was launched with the help of Thomas Henry Huxley, who came to be known as "Darwin's Bulldog"

(Ayala, 2007). In reality, in response to the actual fossil record, Huxley also discretely sought to find a biological mechanism that could account for species seeming to appear suddenly, but he too failed to find such a mechanism (Bowler, 2002; Stark, 2003).

By the time Darwin was 60-years old, he had published his works and offered everything he knew about his theory, but legitimate objections to his theory kept arising and he apparently felt compelled to try to respond to every objection (Wiker, 2009). The most serious challenges to his theory were from a former student of Thomas Huxley, the English anatomist and biologist, Saint George Jackson Mivart (Saint George Jackson Mivart, 2014). As Huxley's student, Mivart began his career as an ardent evolutionist and remained so, but challenged Darwin's proposed mechanism, so set out to confront the weakest points of Darwin's theory of natural selection (Wiker, 2009).

Mivart was "a professor of biology; Fellow and Vice-President of the Zoological Society; Fellow, Secretary, and Vice President of the Linnean Society; Fellow of the Royal Society; he would later get his doctorate in medicine from the University of Louvain" (Wiker, 2009, p. 125). Mivart published his *On the Genesis of Species*, which was the most thorough and serious criticism of Darwin's theory during his lifetime. Mivart's attack was so comprehensive and effective that at one point, Darwin felt as though he should begin anew (p. 125).

Again, Mivart took no issue with evolution itself, but rather, with Darwin's assertion that evolution takes place by means of natural selection (Wiker, 2009). Mivart proposed that natural selection is "incompetent to account for the incipient stages of useful structures" for the reason that these early stages themselves cannot yet contribute to survival, and thus, would not be selected (Mivart, 1871, p. 21). He argued that similar biological structures develop from wholly different origins and random variation is simply inadequate to account for that phenomenon. Mivart proposed biological reasons in support of the idea that the evolutionary transition between species "may be developed suddenly instead of gradually," as Darwin had insisted (p. 21). Mivart noted that "species have definite, though very different limits to their variability" and that "certain fossil transitional forms are absent, which might have been expected to be present" if evolution had progressed slowly through incremental steps (p. 21). Finally, he observed that "there are many remarkable phenomena in organic forms upon which `Natural Selection' throws no light whatever...." (p. 21).

To illustrate the intellectual obstacles one must overcome to accept natural selection as the evolutionary mechanism, Mivart discussed a number of fish that have eyes on both sides of their head when they are young, but as adults their eyes have moved to one side of their head, so they can swim on their side at the bottom of the ocean (Mivart, 1871). He admitted the usefulness for a fish to be able to swim at the bottom of the ocean, while still seeing food sources and potential predators, but "how such transit of one eye a minute fraction of the journey towards the other side of the head could benefit the individual," and each such fraction be chosen as contributing to survival, "is indeed far from clear" (p. 38).

Darwin replied to Mivart’s objections to his theory of natural selection by adding a section to the sixth edition of his *Origin of Species* (Wiker, 2009), in which he offered well formulated explanations for some of Mivart's objections to his theory and fell short regarding others. His explanation to Mivart in relation to flounder fish was that a young flounder may fall over sideways because of the distribution of bodyweight, and as a result, would have to strain its bottom eye in an effort to see forward and upward. He reasoned that over time this straining by the fish would lead to "an inherited malformation in the skull and a wandering eye" (as cited in Wiker, 2009, p. 127).

Darwin's inadequate response regarding flounder and other fish with both eyes on one side of their head did not escape Mivart and other contemporary critics of natural selection (Wiker, 2009). Mivart noted that one could legitimately ask how natural selection could account for the survival of a fish with such an impractical body weight distribution. It seems manifestly unreasonable that natural selection, wherein the fittest survive, could account for the selection of the incremental steps that led to the ill-fitted characteristic or trait, wherein a fish flops over on its side and has to strain to see forward and upward, so much so that the straining slowly distorts its skull. Darwin's critics also wondered how the incremental steps leading to the malformation of the skull that was caused by flopping and straining one eye, could be of any benefit whatsoever, and more importantly, how the required incremental deformities in the skull would be inherited (p. 127-128).

Following Mivart's challenge, Darwin resumed his research, wherein he set out to connect human facial expressions to animal origins (Wiker, 2009). In 1872, Darwin published his *The Expression of the Emotions in Man and Animals*, as the culmination of his research into facial expressions. In keeping with his methodology, he looked to the smallest details for evidence in support of his theory of natural selection. Thus, he concluded that traits such as the movement of a dog's ears amounted to smiling and laughter and connected the narrowing of the eyes in anger to both man and beast.

By the end of his life, Darwin’s name became synonymous with evolution, and in fact, evolution came to be defined in exclusively Darwinian terms (University of Iowa, n.d.; Wiker, 2009). In spite of the fact that during Darwin’s lifetime serious challenges to natural selection as the mechanism by which evolution transpires were not sufficiently answered, the scientific community was undeterred from wholly adopting natural selection as the conventionally accepted evolutionary mechanism. But then a more curious development arose within the scientific community, which speaks to the historical relationship of faith and science (Spitzer, 2010) and is directly linked to the enduring creationist versus Darwinist conflict (David & Kenyon, 1993; Larson, 2003).

Darwin’s groundbreaking book is entitled, *On the Origin of Species by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life*. Notwithstanding the fact that Darwin never revealed how species or any other living organisms originate, the fundamental assumption that evolution somehow ‘proved’ God is excluded from the creative process or simply does not exist, became a virtual ‘law’ of modern science (Dawkins, 2006; Harris, 2004; Spitzer, 2010). That empirical science can somehow prove or disprove God’s existence is simply beyond the realm of the scientific methodology for the reason that empirical science is restricted to the study of natural phenomena. Thus, empirical investigation is simply incapable of making theological judgments of any kind and to venture beyond nature is simply beyond the purview of science.

For his part, Darwin returned to answering his critics' objections to his theory. One such objection, which Darwin approached with fervor, concerned the means of genetic inheritance.

Darwin's Theory of Heredity

This comprehensive analysis of the various elements of Darwin's theory of evolution is necessary in light of the research question herein that concerns the lasting conflict over Darwinism that continues to disrupt science education in United States public schools. One such crucial element of his theory concerns precisely how hereditary characteristics are passed down generationally.

During his lifetime, many of Darwin's critics within the scientific community did not necessarily question whether or not the evolution of living organism takes place, but questioned Darwin's proposed evolutionary mechanism (Wiker, 2009). His critics doubted whether or not random mutation coupled with natural selection is in fact the mechanism which accounts for the enormous variety of life forms of the past and present. In response to his critics, Darwin set out to explain precisely how new genetic information arises and is then passed down generationally. He called his now disproven theory of inheritance, pangenesis (Darwin, 1868).

Darwin's pangenesis theory culminated with the publication of his *The Variation of Animals and Plants under Domestication* (1868). Darwin wrote that he was "forced" by the facts of biology to explain the precise means by which hereditary characteristics are past down generationally and give rise to new species (Darwin, 1868, p. 357). Pangenesis was not a tangent aspect of Darwin's theory of evolution, but the central explanation of his proposed evolutionary mechanism. He first began to write extensively in his personal notebooks about pangenesis between 1836 and 1844 and continued to develop his ideas for several decades (Bergman, 2011; Vorzimmer, 1970). Darwin confidently claimed that his theory of pangenesis would explain: (1) the origin of variation, (2) all aspects of genetic phenomena, and (3) all of the laws of inheritance (Vorzimmer, 1970).

Darwin's theory of pangenesis proposed that every part of a living organism (i.e., heart, lungs, leaves, seeds, etc.) contains microscopic "gemmules" and each gemmule contains the potential to reproduce that part of the organism (i.e., heart, lungs, leaves, seeds, etc.) (Darwin, 1868, p. 396). He proposed gemmules are circulating through the fluids within the organism and make their way to the "sexual elements" (p. 397). Thus, Darwin proposed that pangenesis via gemmules circulating through the fluids, accounts for the means by which a particular characteristic within any part of an organism is passed down to offspring. He summarized his theory:

> The chief assumption is that all the units of the body, besides having the universally admitted power of growing by self-division, throw off minute gemmules which are dispersed through the system…the gemmules grow, multiply, and aggregate themselves into buds and the sexual elements (p. 396-397).

He further explained (Darwin, 1968):

> The gemmules thrown off from each different unit throughout the body must be inconceivably numerous and minute…But the same cells may long continue to

> increase by self-division, and even become modified by absorbing peculiar nutriment, without necessarily throwing off modified gemmules. All organic beings, moreover, include many dormant gemmules derived from their grandparents and more remote progenitors, but not from all their progenitors (p. 397).

Darwin went on to propose that living organisms are altered by environmental conditions and even those changes are passed down through the circulation of gemmules (Darwin, 1968). Thus, he concluded that even changes resulting from exercise are carried through the bodily fluids and passed down to offspring, so a parent with a large muscle mass gained through exercise would pass down large muscle mass to its progeny (Bergman, 2011). In fact, a cornerstone of Darwin's evolutionary theory is the claim that species adapt to their environment (i.e., finches beaks adapt to the structure of their main food source) (Darwin, 1993), so if a rugged environment requires a large muscle mass, according to Darwin's theory, a large muscle mass must be inheritable.

Attempted Verification of Pangenesis

In the late 1860's, Darwin's cousin, Francis Galton was writing a book on heredity and was extremely enthusiastic about Darwin's pangenesis theory (Bergman, 2011). Galton designed an experiment to empirically test his cousin's theory and Darwin was eager to learn the results. The two men corresponded throughout the process, which involved the transfer of blood between rabbits to determine if new characteristics would arise in the offspring. Galton and Darwin agreed that if the pangenesis theory was correct, the gemmules present in the rabbit's blood would transfer characteristics between black and silver-grey rabbits to produce offspring that would exhibit the transferred color characteristics.

Galton devised every possible combination, including a control group (Bergman, 2011). He eventually bread 124 offspring in 21 different litters, but to his great disappointment, not a single “mongrel” rabbit was produced (Gillham, 2001, p. 175). When Darwin learned of his cousin’s findings, he was uncharacteristically angry with him. Soon after, Darwin began to claim that his theory of pangenesis did not involve the blood. His cousin retorted with a feigned contrition and sarcastically apologized for misinterpreting his cousin’s theory (Moore, 1999). Notwithstanding Galton’s experimental results, for the remainder of his life, Darwin continued to maintain that his theory of pangenesis was valid and in spite of evidence to the contrary, many of his scientific contemporaries agreed. Darwin’s theory of pangenesis has since been discredited and now represents a failed attempt to explain the Darwinian evolutionary mechanism, particularly as it relates to inheritance (Moore, 1999; Vorzimmer, 1970).

Continued Search for the Evolutionary Mechanism

Darwinists were originally very optimistic about the prospects that genetics may account for the sudden emergence of new species, but by the turn of the 20th century it had been confirmed that their hopes were ill-founded (Stark, 2003). The most prominent biologists concurred with the findings of the Augustinian monk and celebrated geneticist, Gregor Mendel (1822–1884), who empirically verified that the features of both parents do not blend to form new types of offspring. Mendel confirmed that cross-breeding is not a factor in the progressive development of species because forms of different degrees of organization do not cross, and even if they did cross, the laws of chance and probability would soon equalize any deviations (Muckermann, 1909).

Faced with Mendel's evidence against gradualism, Darwinists then turned to placing their hopes in genetic mutations to account for the sudden appearance in the fossil record of new, fully formed species (Stark, 2003). Due to the apparent absence of transitional forms, Darwinists hoped biologists and geneticists could discover how a vast number of advantageous mutations could occur simultaneously or virtually simultaneously, which could result in a new species without the necessity of incremental steps. Faced with mounting evidence opposing gradualism, leading Darwinists of the 20th and 21st century reversed their strategy and began to argue that new species emerge abruptly (Goldschmidt, 1940; Gould, 1972).

Though Linnaeus had previously asserted that nature takes no leaps (Linnean Society of London, n.d.) and Darwin had said relying on sudden changes would be tantamount to hoping in miracles (Darwin, 1993), his followers were left to explain the apparent sudden emergence of species within the fossil record (Wiker, 2009). Thus, the mid-20th century Neo-Darwinist, Richard Goldschmidt, proposed a solution that he called the "hopeful monster," which proposed that an accumulation of genetic abnormalities produce genetic monstrosities within a single genetic step, resulting in new types (Goldschmidt, 1940). Goldschmidt did, however, acknowledge that cases of multiple mutations normally result in a hopeless monster, wherein the genetic affects are negative, harmful, or retrograde in nature, but still proposed that a hopeful monster is possible and would bring about a new type.

Goldschmidt (1940) was in agreement with the Neo-Darwinian claim that a gradual accumulation of small mutations sufficiently explains microevolution, but rejected the notion that an accumulation of small mutations sufficiently explains the leap between species. He proposed that a different mechanism is required to explain speciation (i.e., macroevolution).

Goldschmidt (1940) asserted that the fossil record indicates that a variety of species exist, which seem to have suddenly emerged with no traceable ancestors. He concluded that the only logical assumption was that multiple, advantageous mutations must have arisen suddenly. A Darwinist colleague, Ernst Mayr, identified the great impediment to accepting Goldschmidt’s "hopeful monster" hypothesis:

> The occurrence of genetic monstrosities by mutation…is well substantiated, but they are such evident freaks that these monsters can only be designated as “hopeless”. They are so utterly unbalanced that they would not have the slightest chance of escaping elimination through selection (Mayr, 1970, p. 253).

Gould (1980) noted that many of his colleagues in the scientific community, unfairly treated Goldschmidt as “their whipping boy” for having the impudence to expose the lack of evidence for gradualism in nature (para. 8). But as a paleontologist and evolutionary biologist, Gould was an expert in the fossil record and concurred with Goldschmidt’s unpopular conclusions. Significantly, Gould also claimed that in spite of Darwin’s own words, the abrupt appearance of new species resulting from the sudden emergence of a cluster of advantageous mutations is not inconsistent with Darwinism (Gould, 1977).

Stephen Jay Gould was arguably the most renowned Neo-Darwinist of the 20th century (Stark, 2003) and made his own effort to explain the presence of apparently fully formed species within the fossil record (Gould, 1977). He proposed a similar alternative to Goldschmidt's hopeful monster theory, which he termed *punctuated equilibrium*. However, Gould never specifically defined the term *punctuated equilibrium* and admitted it is essentially a refining of and representation of Goldschmidt's position. He published an essay entitled *Return of the Hopeful Monster* (1977), wherein he once again, candidly admitted that Darwin had been mistaken in his assertion that the evolutionary process occurs gradually through a succession of small steps.

Gould (1980) acknowledged that Darwin himself had asserted that evolution involves a two-step process, encompassing natural selection via random mutation and that evolutionary development is "slow, steady, gradual, and continuous" (para. 3). Gould, however, conceded that the absence of transitional types within the fossil record simply does not support the gradual development of the tremendous variety of species. Previously, Gould (1977) had conceded:

> The extreme rarity of transitional forms in the fossil record persist as the trade secret of paleontology. The evolutionary trees that adorn our textbooks have data only at the tips and nodes of their branches; the rest is inference, however reasonable, not the evidence of fossils…We fancy ourselves as the only true students of life's history, yet to preserve our favored account of evolution by natural selection we view our data as so bad that we never see the very process we profess to study (p. 14).

In point of fact, many present-day Neo-Darwinists believe Darwin's claim of gradualism to be mistaken (Schuster, 2008).

Gould (1980) noted that Neo-Darwinists make authentic observations like the replacement of light moths by dark moths in correlation with the increase of industrial soot in England; and then proceed to extrapolate the results in predictable ways that are consistent with Darwin's proposed evolutionary mechanism. Neo-Darwinists proceed to describe:

> …the most profound structural transitions in the history of life: by a long series of insensibly graded intermediate steps, birds are linked to reptiles, fish with jaws to their jawless ancestors…If black moths can displace white moths in a century, then reptiles can become birds in a few million years by the smooth and sequential summation of countless changes. The shift of gene frequencies in local populations is an adequate model for all evolutionary processes—or so the current orthodoxy states (para. 4).

Gould (1980) also noted that the fallacies pertaining to the fossil record, along with the extrapolations of data by his Darwinist colleagues, are incessantly repeated in introductory biology textbooks. He provided the following excerpt from an American biology textbook:

> [Can] more extensive evolutionary change, macroevolution, be explained as an outcome of these microevolutionary shifts? Did birds really arise from reptiles by an accumulation of gene substitutions of the kind illustrated by the raspberry eye-color gene? The answer is that it is entirely plausible, and no one has come up

> with a better explanation…The fossil record suggests that macroevolution is indeed gradual, paced at a rate that leads to the conclusion that it is based upon hundreds or thousands of gene substitutions no different in kind from the ones examined in our case histories (as cited in Gould, 1980, para. 5).

Gould (1980) concluded that: (a) continuous change cannot explain all macro-evolutionary events; (2) theories proposing abrupt or sudden change are not anti-Darwinian; and (3) Goldschmidt's hopeful monsters are not only consistent with the fossil record, but represent the best explanation of the evidence and do not represent "the archetype of apostasy from Darwinism," (para. 9) as many of his colleagues have suggested (Dennett, 1996).

Gould was a distinguished scholar, renowned Darwinist, a professor of paleontology and evolutionary biology at both Harvard University and New York University, and a contributor to the American Museum of Natural History in New York (American Academy of Achievement, 2009). But, like Goldschmidt before him, his credentials did not lessen the anger heaped upon him by his peers. In one uncharacteristically light hearted exchange, a critic flippantly referred to Gould's punctuated equilibrium as "evolution by jerks" (Turner, 1984, p. 35). Gould responded by describing gradualism as "evolution by creeps" (Gould & Rose, 2007, p. 6).

The great difficulty with the Neo-Darwinist hopeful monster theory is that the sudden immergence of new species, according to Darwin, is inconsistent with his theory of natural selection and tantamount to relying on miracles (Darwin, 1993). Moreover, a genetic mutation in the form of a hopeful monster (i.e., a creature that exhibits multiple advantageous mutations, completely unlike other members of its species) has never been observed in nature. Although, Darwinists concede the inverse is true, hopeless monsters have been observed many times (Mayr, 1970). Nonetheless, many Neo-Darwinists that acknowledge the sudden emergence of apparently fully formed species (Gould, 1977), continue to search for the evolutionary mechanism that can explain this phenomenon, and have not resorted to miracles as an explanation.

Modern scientists have, however, not only questioned Darwin's proposed evolutionary mechanism (Gould, 1980), but also offered alternative evolutionary mechanisms based on empirical observation. For example, in 2013, a group of scientists from the University of Maryland, the Marine Biological Laboratory (MBL), and Harvard Medical School's Department of Genetics, published an article in the journal *Science*, asserting that they have discovered evidence for an evolutionary mechanism totally distinct from natural selection involving spontaneous arising mutations (Rohner et al., 2013).

The group of scientists studied blind cavefish in Mexican caves, as a means to observe evolution in action (Rohner et al., 2013). The researchers were led by Nicolas Rohner and Clifford J. Tabin from Harvard Medical School's Department of Genetics. They demonstrated how "standing" or "cryptic" genetic variations, which were inherited from earlier generations without triggering any physical changes in the animal, can be "unmasked" by the trauma of suddenly entering a new environment (Kenney, 2013, para. 3). Their discovery marked the first time this evolutionary phenomenon has been observed in nature, wherein gene variants that increase the animal's ability to adapt to their new environment are not only selected for, but are also passed on to offspring. This evolutionary process is entirely distinct from the established evolutionary mechanism of "de novo" genetic mutations, which are said to arise through random chance after the animal has entered a new environment, as proposed by the theory of natural selection (para. 2).

Research into evolutionary science and its various elements continues and modern scientific development has greatly escalated the process. Molecular biology has confirmed common ancestry among living things, which Darwin predicted (Ayala, 2010; Behe, 2007; Horn & Wiedenhofer, 2008), but the debate among academics as to whether random mutation coupled with natural selection can account for the diversity of species has not subsided in a century and a half.

Academics Continue to Debate Darwinism

Despite the fact that most Darwinists claim that Darwin solved the problem of how life came to exist on earth and subsequently evolve into millions of different forms (Dawkins, 1996; New York Times, 2005), their claims have failed to convince a large part of the population (Pew Research, 2006), including many scholars and even some Neo-Darwinists (Raup, 1984; Stark, 2003; Wiker, 2011). Again, the debate among scholars is not whether or not life forms evolve. That life forms evolve is an indisputable fact (Ayala, 2010; Muckermann, 1909; Horn & Wiedenhofer, 2008; Skehan & Nelson, 2000). The debate among scholars concerns whether or not Darwin's proposed mechanism is in fact the mechanism by which evolution takes place (Depew, 2013; Depew & Weber, 2011). Evangelical creationists mistakenly interpret the debate concerning the evolutionary mechanism as evidence against evolution and the creationist misconception is carried over into science classrooms across the United States (Moore & Cotner, 2013).

As expressed previously, any perceived challenge to Darwin's theory of evolution is perceived by many within and outside the scientific community, as a challenge to the theory of evolution itself (Stark, 2003). The unfortunate consequence of discounting any criticism of Charles Darwin's proposed evolutionary mechanism as reactionary is that it serves to stifle scholarly discussion. Still, some scientists do question the validity of Darwin's proposed mechanism and others seek scientific alternatives. For example, ResearchGate is a networking site for research scientists, wherein scientists can ask and answer questions of peers, share research concepts and papers, and locate research associates (ResearchGate, 2014). On June 21, 2012, a research scientist posted the following question on ResearchGate: "Is there a scientific alternative to Neo-Darwinism for understanding biological evolution" (Brassard, 2012). By March 3, 2014, Brassard's question had garnered 1, 273 responses from his peers.

In spite of ResearchGate (2014) and the relatively few similarly designed collaborative websites for scientists and other scholars, authentic research into questions related to evolution is made more difficult by the contemporary creationist versus Darwinist argument that rages on the Internet. A researcher must first circumvent millions of websites that are dedicated to what amounts to largely uninformed, incessant chatter between creationists and their mostly atheist adversaries. For example, on March 3, 2014, the following search: "evolution and Darwin and creationism and atheist" retrieved 2, 260,000 results on www.google.com, which indicates the extent to which the debate rages within popular Western culture.

One of the common characteristics of Darwinists from the beginning has been an unquestionable faith in the theory (University of Iowa, n.d.; Stark, 2003; Wiker, 2009). Gould raised the ire of his peers by merely acknowledging the need – even urgent need – to find a solution to the dilemma associated with the fossil evidence. The outspoken advocate of Darwinism, Daniel C. Dennett, questioned Gould's orthodox faith in Darwinism itself and observed, "my diagnosis, however, is that he [Gould] has all along been hoping for skyhooks [to lift evolution along]" (Dennett, 1996, p. 298).

Stark (2003) noted that the word "miracle" seems to be increasingly utilized, as mathematical assessments are constructed to describe the incredible improbability "that even very simple biochemical chains, let alone living organisms, can occur by a process of random trial and error" (p. 184). For generations, Darwinists, including Huxley himself, have claimed that given an infinite period of time, a monkey at a typewriter would eventually, albeit by accident, produce a Shakespearean play. The difficulty is that evolution has not had an infinite period of time to develop, inasmuch as empirical science has established the approximate age of the universe (Spitzer, 2010), Earth, and the approximate time when life forms first appeared on Earth (University of California Museum of Paleontology, 2011).

Distinguished mathematicians have investigated the Darwinists' claim concerning the monkey at the typewriter and calculated that for a monkey to accurately reproduce only a few lines of *Macbeth*, much less the entire play, "the probability is far, far beyond any possibility… The odds of creating even the simplest organism at random are even more remote – Fred Hoyle and Chandra Wickramasinghe calculated the odds as 1 in $10^{40,000}$" (Stark, 2003, p. 184). All of the atoms contained in the entire universe are estimated to be no more than 10^{80}. Stark concluded that in a very real sense, the Darwinists' claims rest on miraculous, or at minimum, enormously improbably assumptions.

In a book denouncing creationist arguments, the University of Chicago professor of paleontology, David M. Raup (1984), offered an honest assessment of the extant fossil record:

> Darwin predicted that the fossil record should show a reasonably smooth continuum of ancestor-descendant pairs with a satisfactory number of intermediates between major groups. Darwin even went so far as to say that if this were not found in the fossil record, his general theory of evolution would be in serious jeopardy. Such smooth transitions were not found in Darwin's time...We are now more than 100 years after Darwin's time and the situation is little changed. We actually may have fewer examples of smooth transitions than we had in Darwin's time, because some of the old examples turned out to be invalid when studied in more detail (p. 158).

Faced with the fossil evidence, many Darwinists continue to search for the biological mechanism that can account for the sudden emergence of new species (Stark, 2003; Wiker, 2009). Other orthodox Darwinists, do occasionally express their amazement with the fossil evidence, but then simply fall back on natural selection as the only acceptable evolutionary mechanism. Dawkins (1996) is a case in point, as he expressed his unshakable confidence in natural selection:

> My argument will be that Darwinism is the only known theory that is in principle capable of explaining certain aspects of life. If I am right it means that, even if there were no actual evidence in favour of Darwinian theory (there is, of course) we should still be justified in preferring it over all rival theories (p. 287).

Stark (2003) noted the 1999 review in *Nature*: *International Journal of Science*, wherein the Hungarian theoretical evolutionary biologist, Eors Szathmary, reviewed a book by biologist Jeffrey Schwartz, wherein Schwartz put forth an inventive effort to account for the emergence of new life forms:

> The origin of species has long fascinated biologists. Although Darwin's major work bears it as a title, it does not provide a solution to the problem. Does Jeffrey Schwartz give one? I'm afraid that, in general, he does not (Szathmary, 1999, p. 1).

In spite of the great difficulties Darwinists were facing and continue to encounter, their faith in evolution by way of natural selection has remained steadfast. For instance, in the mid-20th century, the grandson of “Darwin’s Bulldog” Julian Huxley, proclaimed, “Darwin's theory is…no longer a theory but a fact" (as cited in Stark, 2003, p. 185). Daniel Dennett, expressed his enthusiasm: “If I were to give an award for the single best idea anyone ever had, I'd give it to Darwin, ahead of even Newton or Einstein and everyone else” (Dennett, 1996, p. 21). In 2005, the noted atheist and Neo-Darwinist Richard Dawkins, expressed the characteristic faith shared by Darwinists from the beginning: “I believe, but I cannot prove, that all life, all intelligence, all creativity and all ‘design’ anywhere in the universe, is the direct or indirect product of Darwinian natural selection” (New York Times, 2005, para. 7). On another occasion Dawkins echoed Julian Huxley's claim made more than a century before, "the theory is about as much in doubt as the earth goes round the sun" (as cited in Stark, 2003, p. 177).

Academics continue to debate the merits of Darwin’s theory, although the scholarly debate is much less well known than the debate that rages in the popular media. Even less well publicized are the incredible statements and explanations offered by Darwin, as he diligently worked to explain his theory and its application within society as a whole.

Consequences of Applied Darwinism

Darwin’s own words must be examined in order to reach a comprehensive understanding of why objections to Darwinism first arose and why various objections have still not abated. It is the case that criticism began as soon as Darwin and his closest disciples began the process of explaining his theory. Although they are the most outspoken critics of Darwinism, evangelical Christian creationists are not by any means the theory’s only detractors. This section contains several direct quotes from Charles Darwin and his closest collaborators, which will serve to illuminate why many disavow his theory.

As Darwin and his most committed disciples continued to explain his theory and expound on its various social, anthropological, and psychological implications (Darwin, 1871; Darwin, 1882), many became increasingly repelled by applied Darwinism (Wiker, 2009; Stark, 2003). Based on Darwin's own explanations of his theory and those of a host of 19th and 20th century men of science, Darwinism ultimately came to repulse many on both moral and religious grounds. Moreover, it is certain that if a present-day academic were to publish statements even remotely similar to those made by Charles Darwin and many of his disciples; 21st century moral and ethical sensibilities would be severely offended. A comparatively small selection of only a few of the abhorrent assertions made by Darwin and a few of his disciples are provided below, which reveal the underlying rationale for much of the general opposition to Darwinism past and present.

One may argue that Darwin's controversial teachings are correctly understood as products of the social circumstances and the era in which he lived. But that does not account for his repeated lapses into specious reasoning, through which he often arrived at the most distressing and often absurd conclusions. Moreover, it is a curious fact that his research conclusions continually reinforce 19th century attitudes and prejudices. To be clear, scientists are free to explain their theories and interpret the implications of their research as they see fit, but others are free to challenge their assumptions and conclusions and Darwin's theory is no exception in that regard.

Based on his theory of natural selection, Darwin understood human beings as biological animals, who possess no more intrinsic value than any other biological creature (Darwin, 1871). In accordance with his theory, in the first edition of his book *The Descent of Man, and Selection Related to* Sex (1871), Darwin goes to incredible lengths to prove "civilised races of man" have reached a far more advanced state of evolution than the lower "savage races" (p. 112). As Darwin meticulously described his theory of human evolution, he repeatedly made comparisons of the lower "savages" to apes and dogs: "Apes are much given to imitation, as are the lowest savages…" (p. 161). As he described how virtues must have developed through physical evolutionary processes, he wrote of "the praise and blame of fellow-men" and concluded, "it appears that even dogs appreciate encouragement, praise, and blame. The rudest savages feel the sentiment of glory…by their habit of excessive boasting, and even by the extreme care which they take of their personal appearance and decorations..." (p. 164). In the 1871 first edition of *The Descent of Man*, Darwin referred to "savages" a total of 71 different times in 247 pages and many of those references concerned the Aboriginal people of Australia.

Notwithstanding his insistence on gradual, incremental evolutionary steps over geological ages (Darwin, 1964), he asserted the following as evidence that the "lower races" have reached their evolutionary limit: "many savages are in the same condition as when first discovered several centuries ago" (Darwin, 1871, p. 166). He conceded that even the "rudest savages…certainly feel shame at the breach of some of their lesser rules; but how far they experience remorse is doubtful" (p. 164). As further proof of his conclusion that "savages" are apparently incapable of feeling remorse, Darwin referenced the authority of Sir J. Lubbock, who stated that he also know of no such cases (p. 164). Darwin was never for want of "experts" like Lubbock to cite as validation for any of his outrageous claims concerning race and gender inequality. Many members of the 19th century scientific community devoted themselves to conducting "scientific" research in relation to Darwin's popular theory (p. 100). As a result, Darwin never lacked "evidence" in support of his theory concerning the inferior level of evolutionary development of "savages," in comparison to what he judged to be "civilised men" (p. 117).

He perceived that "most savages are utterly indifferent to the sufferings of strangers, or even delight in witnessing them… take a horrid pleasure in cruelty to animals, and humanity with them is an unknown virtue," and "savages" also take great pleasure in "torturing their enemies" (Darwin, 1871, p. 94). "The greatest intemperance with savages is no reproach. Their utter licentiousness, not to mention unnatural crimes, is something astounding" (p. 96). Darwin was certain of "the chief causes of the low morality of savages," and accordingly, he provided the following list: "…firstly, the confinement of sympathy to the same tribe…Secondly, insufficient powers of reasoning" and finally, "savages" possess an obvious "weak power of self-command" (p. 97). Taken all together, Darwin concluded, "common experience justifies the maxim of the Spaniard, 'Never, never trust an Indian'" (p. 95).

In the second and third chapters of *The Descent of Man, and Selection Related to Sex,* Darwin (1871) compared the mental powers of man to the lower animals in his analysis of "the self-regarding virtues acquired at a later stage of development" (p. v). In his discussion of the capacity for self-consciousness, abstraction, and general ideas, he compared the faculty for self-awareness of an old dog to that of an Australian Aboriginal woman. He first addressed the old dog: "But can we feel sure that an old dog with an excellent memory and some power of imagination, as shewn by his dreams, never reflects on his past pleasures in the chase?" and concluded that "this would be a form of self-consciousness" (p. 62). His "scientific" analysis continued as he turned his attention to the Australian Aboriginal woman: "On the other hand…how little can the hard-worked wife of a degraded Australian savage, who uses hardly any abstract words and cannot count above four, exert her self-consciousness, or reflect on the nature of her own existence" (p. 62).

Darwin's scientific methodology was gravely distorted by his marked cultural centrism, as he judged that the native peoples traditional dress, adornments, and favored music clearly revealed that their ability to make complex associations had not evolved to an advanced state and did not even equal the abilities of a bird (Darwin, 1882). "Judging from the hideous ornaments, and the equally hideous music admired by most savages, it might be urged that their aesthetic faculty was not so highly developed as in certain animals, for instance, as in birds" (p. 93). He continued, "…such high tastes are acquired through culture, and dependent on complex associations; they are not enjoyed by barbarians…" (p. 93). Later in the same work, Darwin returned to his analysis of the aesthetic and "savages": "…we should remember what discordant noises, the beating of tom-toms and the shrill notes of reeds, please the ears of savages" and referenced another authority on the subject, "Sir S. Baker remarks, that 'as the stomach of the Arab prefers the raw meat and reeking liver taken hot from the animal, so does his ear prefer his equally coarse and discordant music to all other'" (p. 380).

Gelb (2008) noted the paradox in the following passage, wherein Darwin (1882) extoled the monkey and baboon for possessing human-like virtues, but then, once again, denigrated those he considered to be evolutionary underdeveloped "savages." "He who saw a savage in his native land will not feel much shame, if forced to acknowledge that the blood of some more humble creature flows in his veins" and continued, "for my own part I would as soon be descended from that heroic little monkey…or from that old baboon…as from a savage" (p. 619). He defended his conclusion by once again offering outrageous generalizations regarding native people, observing the "savage…delights to torture his enemies, offers up bloody sacrifices, practices infanticide without remorse, treats his wives like slaves, knows no decency, and is haunted by the grossest superstitions" (p. 619). Thus, for Darwin, admitting descent from a monkey or baboon was more palatable than the shame in admitting relationship with "savage" people.

Status of Women within Darwinism

In the 1874 second edition of *The Descent of Man*, Darwin considered *Secondary Sexual Characters of Man*, wherein he confidently asserted: "Man is more courageous, pugnacious and energetic than woman, and has a more inventive genius" and moreover, "his brain is absolutely larger" (p. 557). He proposed that women are a type of evolutionary intermediate between men and children, as he observed that although the adult woman, "ultimately assumes certain distinctive characters…the formation of her skull, is said to be intermediate between the child and the man" (p. 557), which he thought may account for her inferior inventive genius. Darwin provided the following analysis of the disparity he perceived between the intellectual abilities of men and women:

> The chief distinction in the intellectual powers of the two sexes is shewn by man's attaining to a higher eminence, in whatever he takes up, than can woman - whether requiring deep thought, reason, or imagination, or merely the use of the senses and hands. If two lists were made of the most eminent men and women in poetry, painting, sculpture, music (inclusive both of composition and performance), history, science, and philosophy, with half-a-dozen names under each subject, the two lists would not bear comparison. We may also infer, from the law of the deviation from averages, so well illustrated by Mr. Galton, in his work on 'Hereditary Genius,' that if men are capable of a decided pre-eminence over women in many subjects, the average of mental power in man must be above that of woman (Darwin, 1874, p. 564).

Darwin (1882) also concluded: "With savages, for instance, the Australians, the women are the constant cause of war both between members of the same tribe and between distinct tribes" (p. 561). Darwin asserted that "woman seems to differ from man in mental disposition, chiefly in her greater tenderness and less selfishness; and this holds good even with savages" and claimed "it is generally admitted that with woman the powers of intuition, of rapid perception, and perhaps of imitation, are more strongly marked than in man" (p. 563).

He noted how fortunate it is that human evolution progressed as it did, otherwise men may have evolved to such a superior state over that of women that they might have actually become a completely different species:

> Thus man has ultimately become superior to woman. It is, indeed, fortunate that the law of the equal transmission of characters to both sexes prevails with mammals; otherwise it is probable that man would have become as superior in mental endowment to woman, as the peacock is in ornamental plumage to the peahen" (Darwin, 1882, p. 565).

Evolutionary Adaptations Among the "Civilized"

For Darwin (1871), evidence of the "savages" low level of evolutionary development was not limited to underdeveloped social habits, deficient powers of reasoning, and the inability to experience certain human emotions. For him, comparisons of the physical features of "savages" with those of "civilised men," provided more "proof" of his claims – even differences among the various classes of "civilised men" in England. Thus, his methodology enabled him to even perceive physical differences that had evolved among the various groups in Western society. For example, he carefully noted that research had revealed "that the hands of English labourers are at birth larger than those of the gentry" and did not overlook "the correlation which exists, at least in some cases, between the development of the extremities and of the jaws," which confirms that "it is possible that in those classes which do not labour much with their hands and feet, the jaws would be reduced in size from this cause" (p. 117). Thus, he confidently affirmed that the hands and jaws "are generally smaller in refined and civilised men than in hard-working men or savages, is certain" (pp. 117-118). Although, an explanation as to why the jaw would be smaller as a result of performing less labor with the hands and feet was never offered by Darwin.

Darwin (1871) also noted that a 19th century United States Commission had inadvertently exposed an evolutionary development that had apparently evolved extraordinarily quickly. The commission noted that “the legs of the sailors employed in the late war were longer by 0.217 of an inch than those of the soldiers, though the sailors were on an average shorter men,” but “their arms were shorter by 1.09 of an inch, and therefore out of proportion shorter in relation to their lesser height” (pp. 116-117). Darwin reasoned that “this shortness of the arms is apparently due to their greater use” (p. 117). Previously in the same paragraph, he had noted that when a person loses the use of one kidney, the other grows larger for doing twice the work. But then he immediately inferred that sailors have shorter arms than soldiers because they use their arms more than soldiers use theirs. Thus, Darwin’s theory apparently attributes both an increase in a physical feature’s size and a decrease in a physical feature’s size to the same phenomenon (i.e., its increased use).

Darwinism’s Exploitation of the Mentally Disabled

In 1864, only five years after the publication of Charles Darwin’s *Origin of Species*, anthropologist and President of the National Institution of Geneva, Carl Vogt, published his corresponding research under the title *Lectures on Man: His Place in Creation, and in the History of the Earth* (Gelb, 2008). Vogt claimed to have shown that the “lowest” human races and apes represent a racial hierarchy that clearly demonstrates the evolutionary link between humans and animals. Vogt (1864) attempted to justify his use of the mentally disabled as research subjects by stating, "when the normal form leaves us in the lurch as regards our investigations, we have a right to avail ourselves of abnormal forms, where we may reap a rich harvest" because, he reasoned, "microcephali [i.e., smaller than normal head caused by genetic and environmental conditions] and born idiots present as perfect a series from man to the ape as may be wished for" (pp. 194-195).

Having defended his use of mentally disabled people in his research, Vogt (1864) went on to compare the physiques of "idiots" to animals and claimed that, "the arms seem disproportionately long, the legs short and weak ...We need only place the skulls of the Negro, chimpanzee and idiot side by side, to show that the idiot holds in every respect an intermediate place between them" (Vogt, 1864, pp. 197-198).

Not surprisingly, in his introduction to the first edition of *The Descent of Man,* Darwin (1871) praised Vogt's research and cited his work multiple times (Gelb, 2008). Darwin proceeded to further develop Vogt's thesis that the mentally impaired represent an evolutionary link between humans and animals, "as described in Vogt's great memoir" (p. 121). After having described the physical features and mental capacities of the disabled, Darwin began to draw what he deemed to be a scientific comparison: "They cannot acquire the power of speech, and are wholly incapable of prolonged attention, but are much given to imitation. They are strong and remarkably active, continually gamboling and jumping about, and making grimaces" (p. 121). He noted what he believed to be animal like traits: "They often ascend stairs on all-fours; and are curiously fond of climbing up furniture or trees" similar to "how lambs and kids, originally alpine animals, delight to frisk on any hillock, however small" (pp. 121-122).

In his chapter entitled “Resemblances between idiots and animals” (p. 35) within his 1874 edition of *The Descent of Man*, Darwin added further observations in reference to what he believed to be animal like behaviors among the mentally disabled. He noted “several cases are recorded of their carefully smelling every mouthful of food before eating it. One idiot is described as often using his mouth in aid of his hands, whilst hunting for lice” (p. 36). He then offered additional “evidence” indicating that the mentally disabled represent an evolutionary link between humans and animals: “They are often filthy in their habits, and have no sense of decency; and several cases have been published of their bodies being remarkably hairy” (p. 36).

As noted above, following the 1859 publication of his *Origin of Species*, Darwin was never for want of scientific studies in support of his evolutionary theory (Gelb, 2008). In addition to Vogt (1864), a numerous of scientists set out to research and provide additional substantive support for Darwin’s theory. For example, in 1868, the American geologist, J. Peter Lesley, published his work *Man’s Origin and Destiny*, wherein he set out to disprove the suggestion that missing links had not been found. He noted the existence of “individuals scattered all over the world, through all the human races, with low foreheads, small brains, long arms, thin legs, projecting, tusk-like teeth, suppressed noses, and other marks of arrested development,” and if their existence is not an obvious enough connection, he continued, “to say nothing of millions of idiots and cretins produced by the same arrest in every generation of mankind, sustain the argument” (p. 120).

Lesley (1868) also noted that the "Australian natives" were commonly "accepted as the most degraded or apelike race now living on earth" (pp. 120-121). Thus, because "the resemblance in most cases (setting the Engis [Neanderthal] skull aside) is so extraordinary," people "may be reasonably excused for suspecting that the early races of mankind were farther removed in the order of development from the noblest races now existing than the apes are removed from them" (p. 121). With conspicuous relief and satisfaction, Lesley proclaimed: "Let us praise God for our place in this procession of mysteries" (p. 121).

Gelb (2008) aptly noted that for both Vogt (1864) and Darwin (1874) the mentally disabled represent "a case of reversion" (p. 36), wherein a structure, such as the brain, suffers arrested development, but continues to grow until it resembles a lower or adult member of a population. Thus, Darwin concluded, "the lower members in a group give us some idea how the common progenitor was probably constructed" (p. 36). He left no doubts as to the implications of his theory: "…we may trace a perfect gradation from the mind of an utter idiot, lower than that of an animal low in the scale, to the mind of a Newton" (p. 127). So, Darwin and his closest associates concluded that "idiots" represent a missing link and likely share many physical and mental traits with distant human ancestors.

Darwin and his 19th century colleagues set out to recasting persons with intellectual disabilities into an animal like essence, outside the human pale (Gelb, 2008). The evolutionary usefulness of the mentally disabled was publicly demonstrated by Darwin's protégé, Georges Romanes, who in 1878 gave a presentation on the evolution of intelligence to the British Association for the Advancement of Science. Desmond and Moore (1994) observed that *The London Times* reported that Romanes put "savages, young children, idiots, and uneducated deaf-mutes" on display to demonstrate how "man and brute have much more in common intellectually, and perhaps, even, than is dreamt of" (as cited in Gelb, 2008). The gathering of scientists was so taken by Romanes' presentation that they gave him a standing ovation (Gelb, 2008). Afterwards, Darwin wrote to Romanes: "I am most heartily glad your lecture (just received and read) has been so eminently successful" and then delightfully added, "Frank [Darwin's son] say's you ought to keep an idiot, a deaf mute, a monkey, and a baby in your house" (Lockyer, 1896, pp. 481-482).

Darwin's Critique of Modern Society

In light of his theory of evolution by natural selection, Darwin candidly argued that societies that care for and support the weakest members of society do so to their own detriment (Darwin, 1874). In his 1874 edition of *The Descent of Man*, under the heading *Natural Selection as affecting Civilised Nations*, Darwin referenced research by three of his colleagues, which noted that "with savages, the weak in body or mind are soon eliminated; and those that survive commonly exhibit a vigorous state of health," but then lamented: "We civilised men…do our utmost to check the process of elimination; we build asylums for the imbecile, the maimed, and the sick; we institute poor-laws" and moreover, "our medical men exert their utmost skill to save the life of every one to the last moment" (pp. 133-134).

Even more disconcerting for Darwin (1874) was the fact that: "There is reason to believe that vaccination has preserved thousands, who from a weak constitution would formerly have succumbed to small-pox" and "thus the weak members of civilised societies propagate their kind. No one who has attended to the breeding of domestic animals will doubt that this must be highly injurious to the race of man" (p. 134). He continued: "It is surprising how soon a want of care, or care wrongly directed, leads to the degeneration of a domestic race," but only "man himself" is subject to this evil because "hardly any one is so ignorant as to allow his worst animals to breed" (p. 134).

Darwin (1874) conceded that "we must therefore bear the undoubtedly bad effects of the weak surviving and propagating their kind" (p. 134). He did, however, discern at least one evolutionary check on the weak members of civilized society surviving: "namely that the weaker and inferior members of society do not marry so freely as the sound," which itself, "might be indefinitely increased by the weak in body or mind refraining from marriage, though this is more to be hoped for than expected" (p. 134).

Darwin (1974) argued that "the elimination of those individuals, though few in number, which are in any marked manner inferior, is by no means an unimportant element towards success" of a species (p. 135). He offered the example of the "black sheep" members of society, who, without any discernable "cause make their appearance in families" and "may perhaps be reversions to a savage state, from which we are not removed by very many generations" (p. 135). Darwin speculated that the savage roots of the apparent misfits of society may account for "the common expression that such men are the black sheep of the family" (p. 135).

Darwin (1874) was very critical of the fact that "the very poor and reckless, who are often degraded by vice, almost invariably marry early, whilst the careful and frugal, who are generally otherwise virtuous, marry late in life," so they are able "to support themselves and their children in comfort" (p. 138). To illustrate his point, Darwin referenced Mr. Greg, who pointedly stated the case:

> The careless, squalid, unaspiring Irishman multiplies like rabbits: the frugal, foreseeing, self-respecting, ambitious Scot, stern in his morality, spiritual in his faith, sagacious and disciplined in his intelligence, passes his best years in struggle and in celibacy, marries late, and leaves few behind him…In the eternal 'struggle for existence,' it would be the inferior and *less* favoured race that had prevailed—and prevailed by virtue not of its good qualities but of its faults (as cited in Darwin, 1874, p. 138).

Even so, Darwin (1874) did not completely give in to despair, as he explained there is at least one evolutionary check on "this downward tendency" (p. 137) of the "poorest classes" of society to reproduce at a higher rate than the "superior class" (p. 138) of men. He noted that the mortality rates for the "poorest classes" (p. 137) were higher than those of the civilized "superior" classes (p. 138). Nevertheless, Darwin cautioned that if the evolutionary checks he noted failed to stop "the reckless, the vicious and otherwise inferior members of society from increasing at a quicker rate than the better class of men, the nation will retrograde, as has too often occurred in the history of the world" (p. 140).

The following cryptic statement by Darwin, concerning the extermination of those persons judged by society to be inferior is particularly horrifying, as it came less than six decades before the Nazi atrocities visited upon the Jewish population, the mentally disabled, "Gypsies," and others they judge to be substandard:

> At some future period, not very distant as measured by centuries, the civilised races of man will almost certainly exterminate, and replace, the savage races throughout the world. At the same time the anthropomorphous apes, as Professor Schaaffhausen has remarked, will no doubt be exterminated. The break between man and his nearest allies will then be wider, for it will intervene between man in a more civilised state, as we may hope, even than the Caucasian, and some ape as low as a baboon, instead of as now between the negro or Australian and the gorilla (Darwin, 1874, p. 156).

Wiker (2011) recounted how during the First World War, the most influential Germans used Darwin's theory of evolution to lend scientific credibility to and as validation of their actions. For example, the American entomologist and evolutionist, Vernon Kellogg, reported that on many occasions he witnessed high ranking German officers of the German General Staff, "many of whom had been university professors before the war," discussing the evolutionary rationale and justification for the war using "a particularly crude form of natural selection, defined as inexorable, bloody battle" (Gould, 1991, pp. 422-423). Kellogg noted that the German officers also openly discussed the evolutionary nature of the war in the presence of the Kaiser.

Following the First World War, the German National Socialist Worker's Party, the Nazis, continued to use Darwin's theory to justify their actions (Wiker, 2011). For example, the deputy party leader of the Nazis, Rudolph Hess, forthrightly stated, "National Socialism is nothing but applied biology" (as cited in Wiker, 2011, p. 162). Thus, Creighton University reported that in addition to the extermination of millions of innocent people, the Nazis also recorded the forcible sterilization of 410, 600 individuals (*History of Eugenics*, n.d.):

- Hereditary feeble-mindedness: 200,000
- Schizophrenia: 80,000
- Epilepsy: 60,000
- Manic-depressive psychosis: 20,000
- Serious physical deformities: 20,000
- Hereditary deafness: 16,000
- Hereditary alcoholism: 10,000
- Hereditary blindness: 4,000
- Huntington's chorea: 600

Nineteenth-century Western society elites considered women and people of color to be the Caucasian man's physical, intellectual, creative, and emotional inferior (Darwin, 1882). Darwin's evolutionary theory provided "scientific" support for and lent credibility to a disgraceful perception of both women and people of color. In their seemingly desperate efforts to produce credible missing links, Darwinists also proposed that the mentally impaired are something less than human and are in fact represent an evolutionary link between apes and modern humans. Thus, there is little mystery as to why so many of the leaders of the early eugenics movement were members of the Darwin family, including the originator of the eugenics movement itself, Charles Darwin's cousin, Sir Francis Galton (Galton, 1892).

Galton (1869) authored a book entitled *Heredity Genius*, wherein he documented following six accomplished men from what he judged to be good families. He proposed that it is possible to breed "a highly-gifted race of men," which would counter the influences and social agencies, which, "are at this moment working towards the degradation of human nature" (Eugenics Archive, n.d., para. 3). In the preparatory chapter of the same work, Galton argued: "There is nothing either in the history of domestic animals or in that of evolution to make us doubt that a race of sane men may be formed," more specifically, sane men "who shall be as much superior mentally and morally to the modern European, as the modern European is to the lowest of the Negro races" (Galton, 1892, para. 7). Darwin (1874) expressed his great admiration for Galton's eugenics thesis in the pages of his *Descent of Man*: "we now know, through the admirable labours of Mr. Galton, that genius…tends to be inherited," as are "insanity and deteriorated mental powers" (p. 28). As early as 1869, Darwin wrote to Galton, "I do not think that I ever in my life read anything more interesting and original…you have made a convert of an opponent…a memorable work" (as cited in Bergman, 2011, p. 226).

Soon afterwards, Darwin's two sons became leaders of the eugenics movement (West, 2007). George and Leonard Darwin both strenuously advocated for eugenics and Leonard served as the president of the leading eugenics organization in Great Britain, the

Eugenics Education Society. Charles Darwin later cut off all communication with Mivart, following Mivart's critical review of an article written by Darwin's son George, wherein George had strenuously advocated for eugenics (Bergman, 2011).

Apparent Theoretical Deficiencies within Darwinism

The second subquestion herein enquires as to what importance the historical origins and progress of science hold in informing the continuing creationist versus Darwinist conflict within education. It necessarily follows then that scholarly historical research requires an honest reporting of the history, attributes, adequacies, insufficiencies, and influences of both the creationist and Darwinist positions – even when those facts are uncomfortable. Regrettably, in the case of Darwinism, 21st century scholars and societal leaders are still labouring to reverse the various and related misconceptions concerning women, people of color, and the mentally challenged, which were bluntly postulated by Charles Darwin and those who championed his cause – all under the guise of science (Junco, Merson, & Salter, 2010).

The biological and anthropological evidence in support of the evolution of life forms over immense geological ages is clear (Ayala, 2010). It is an incontrovertible fact that only simple organisms have been found in the oldest geological strata, whereas more complex organisms have been discovered in the more recent strata (Ayala, 2010; Muckermann, 1909; Horn & Wiedenhofer, 2008; Skehan & Nelson, 2000). Moreover, DNA evidence confirms Darwin's concept of common ancestry, wherein all living organisms are in fact biological relatives, including the case of humans and chimpanzees (Ayala, 2010; Behe, 2007; Schuster, 2008). However, common descent itself does not account for the vast dissimilarities between species (Behe, 2007) and Darwin's proposed evolutionary mechanism (i.e., natural selection coupled with random mutation) has not yet accounted for the incredible diversity of life forms (Muckermann, 1909).

In the *Origin of Species*, Darwin himself offered the criteria by which his evolutionary mechanism can be judged, wherein he insisted on "numerous, successive, slight modifications," and he noted that if they were not found, "my theory would absolutely break down" (Darwin, 1964, p. 189). He also rejected the notion that new species could arise suddenly and said to entertain such a theory would be tantamount "to enter into the realm of miracle, and to leave those of Science" (Darwin, 1993, p. 316). But even in his own lifetime, he was perplexed by the lack of evidence in support of gradualism and wondered why the fossil record lacks evidence of species "descended from other species by fine gradations," and asked, "Why is not all nature in confusion instead of the species being, as we see them, well defined (Darwin, 1993, p. 212)? On yet another occasion he admitted:

> But I do not pretend that I should ever have suspected how poor a record of the mutations of life, the best preserved geological section presented, had the difficulty of our not discovering innumerable transitional links between the species which appeared at the commencement and close of each formation, [which] pressed so hardly on my theory (London Quarterly Review, 1923/2012, p. 128).

Twenty-first-century Darwinists, such as, Richard Dawkins (1996), remain perplexed by the apparent lack of missing links. Dawkins expressed his bewilderment in regards to the Cambrian evidence from 600 million years ago, in which the oldest major invertebrate groups were found “already in an advanced state of evolution, the very first time they appear…as though they were just planted there, without any evolutionary history (p. 229). The evolutionary biologist and paleontologist, Steven Stanley, confirmed: "The known fossil record…offers no evidence that the gradualistic model can be valid" (as cited in Stark, 2003, p. 180). The apparent sudden emergence of fully formed species is perplexing, but a naturalistic, scientific explanation may very well be found, which accounts for this phenomenon. But Charles Darwin would be the first to admit that his proposed evolutionary mechanism (i.e., natural selection coupled with random mutation) has thus far been incapable of accounting for the sudden emergence of species.

Science or Crusade

When *The Origin of Species* was first published it was received with great enthusiasm by both the scientific and religious communities (Stark, 2003). However, that churchmen accepted Darwin's theory of evolution through natural selection was not only confusing, but vexing to the original Darwinists, who had hoped to refute religious claims concerning a Creator. Although Darwinists now claim that from the beginning they have bravely withstood repeated attacks from religion, history records that from the beginning virtually all of the major Christian denominations lauded Darwin’s new theory. For example, the Harvard biologist Asa Gray (1810–1888) praised Darwin for, in his view, solving the most difficult problems confronting the Design Argument. Gray willingly acknowledged that Darwin rejected the idea of design, but still hailed him for "bringing out the neatest illustrations of it" (as cited in Stark, 2003, p. 185).

On the whole, Darwin and his most committed disciples found the religious community's general acceptance of his theory to be intolerable (Stark, 2003). In 1859, Darwin's "bulldog" Huxley, bluntly stated the hostility early Darwinist's held toward religion:

> My screed was meant as a protest against Theology & Parsondom…both of which are in my mind the natural & irreconcilable enemies of Science. Few see it but I believe we are on the Eve of a new Reformation and if I have a wish to live thirty years, it is to see the foot of Science on the necks of her Enemies (as cited in Stark, p. 186).

Huxley's disdain for religion surfaced on yet another occasion:

> Extinguished theologians lie about the cradle of every science as the strangled snakes beside that of Hercules; and history records that whenever science and orthodoxy have been fairly opposed, the latter has been forced to retire from the list, bleeding and crushed if not annihilated, scotched, if not slain (as cited in Royal, 2006, p. 231).

Lucas (1979) observed that even late in life, Huxley was "still remarkably resistant to the idea that there were clergymen who accepted evolution, even when actually faced with them" (as cited in Stark, p. 186). The Darwinian Crusade against religion only began with Darwin and Huxley, but has been vigorously pursued since their time. In a presidential address to the British Association in 1874, the 19th century physicist John Tyndall (1820–1893) expressed an early Darwinist goal: " We claim and we shall wrest from theology, the entire domain of cosmological theory" (as cited in Stark, p. 186).

Darwin's German advocate, Ernst Haeckel, complained that the care of the sick and infirm of society, results in the "sad fact that...weakness of the body and character are on the perpetual increase among civilized nations...." and candidly asked: "What good does it do to humanity to maintain artificially and rear the thousands of cripples, deaf-mutes, idiots, etc., who are born every year with an hereditary burden of incurable disease" (as cited in Wiker, 2011, p. 159). He went on to complain that "Christianity forbids" their destruction, but the Christian opposition is "only due to sentiment and the power of conventional morality" (as cited in Wiker, 2011, p. 159).

Ernst Haeckel was clear about who he considered to be the real enemy of social progress:

> On one side spiritual freedom and truth, reason and culture, evolution and progress stand under the bright banner of science; on the other side, under the black flag of hierarchy, stand spiritual slavery and falsehood, irrationality and barbarism, superstition and retrogression…Evolution is the heavy artillery in the struggle for truth. Whole ranks of…sophistries fall together under the chain shot of this…artillery, and the proud and mighty structure of the Roman hierarchy, that powerful stronghold of infallible dogmatism, falls like a house of cards (Haeckel, 1874, pp. xiii-xiv).

For his part, Darwin expressed his great admiration for Haeckel and informed him that among those carrying on his theory, he considered Haeckel “to rank as the first” (as cited in Wiker, 2011, p. 158).

More recently, the former Oxford professor of biology, outspoken Darwinist, and now seemingly professional atheist, Richard Dawkins, offered this assessment of natural selection:

> Natural selection, the blind, unconscious, automatic process which Darwin discovered, and which we now know is the explanation for the existence and apparently purposeful form of all life, has no purpose in mind. It has no mind and no mind’s eye. It does not plan for the future. It has no vision, no foresight, no site at all. If it can be said to play the role of watchmaker in nature, it is the blind watchmaker (Dawkins, 1996, p. 5).

Dawkins described, not just evolution, but the science of biology itself, as "the study of complicated things that give the appearance of having been designed for a purpose" (as cited in Wiker, 2011, p. 60). He articulated his absolute intolerance for the opposition: “It is absolutely safe to say that, if you meet somebody who claims not to believe in evolution, that person is ignorant, stupid, or insane” (as cited in Stark, 2003, p. 177).

Goldschmidt, Schwartz, Eldredge & Gould, and many others have attempted to offer solutions to the discrepancies between Darwin’s claim of gradualism in nature and the contradictory fossil evidence (Stark, 2003). Through the years, Szathmary, Mayr, and several others have put forth various explanations for the lack of empirical evidence in support of Darwin's natural selection. But even the exercise of simply proposing explanations is deemed unacceptable by staunch Darwinist's like Dawkins, who insist on orthodoxy of belief and unity among Darwinists. Dawkins actually went so far as to propose that any doubts in the minds of Darwinist's should be kept as a sort of "trade secret" (p. 177) and that only true believers in evolution should be party to the conversation. For example, Dawkins accused the distinguished Darwinists, Eldredge & Gould, of giving "spurious aid and comfort to modern creationists" because "if a reputable scholar breathes so much as a hint of criticism of some detail of Darwinian theory, the fact is seized upon and blown up out of proportion" (as cited in Stark, 2003, p. 177).

For his part, Gould admitted that "the extreme rarity of transitional forms in the fossil record" is a major source of embarrassment for Darwinists and also confessed that the truth of the fossil record has been held as a "trade secret of paleontology" for decades (as cited in Stark, 2003, p. 177). Significantly, Gould also acknowledged that the evolutionary charts "that adorn our textbooks", such as those which depict a series of pictures of a primate progressing to an upright human being, are sole based on "inference…not the evidence of fossils" (as cited in Stark, 2003, p. 177). The distinguished evolutionist, Steven Stanley, divulged that doubts that resulted from the problem with the fossil record were "suppressed" for years and added that the suppression of any misgivings related to Darwinism was begun by none other than "Darwin's bulldog" Huxley. Eldredge bluntly summed up the situation: "We paleontologists have said that the history of life supports [the principle of gradual transformations of species], all the while really knowing that it does not" (as cited in Stark, 2003, p. 178).

Ideological crusades suppress and filter the known facts, whereas, genuine empirical science seeks to explain natural phenomena – even when the explanation does not support a particular theory.

Charles Darwin was not by any means the first to propose evolutionary theory (Wiker, 2011). He did, however, proposed an evolutionary mechanism (i.e., natural selection coupled with random mutation) and then for the remainder of his life, he and his disciples set out to explain his theory's rationale. Darwinism, as articulated by Darwin and his closest collaborators, included numerous horrifying implications for society – implications that soon emerged in the 20th century (Darwin, 1874). But for some present-day Darwinists like Richard Dawkins, it is not at all clear that the Nazi and others' actions against the weakest members of society, were wrong or immoral (Taunton, 2007). For example, in a response to a question concerning what standard can be used to judged moral behavior, Dawkins exclaimed, "Yes, absolutely fascinating. What's to prevent us from saying Hitler wasn't right? I mean, that is a genuinely difficult question" (para. 25). From a Darwinist perspective, Dawkins was right in his assessment of Hitler because as Darwin (1874) wrote, "the elimination of those individuals, though few in number, which are in any marked manner inferior, is by no means an unimportant element towards success" of a species (p. 135).

In light of the above account of Darwin's theory and its implications for society, it seems inconceivable that Western nations would entertain the idea of a national holiday celebrating Darwin. But the crusade for Darwinism has not diminished and is being carried on in 2014 by organizations such as the *International Darwin Day Foundation: Celebrating Darwin, Science and Humanity,* which seeks "a global celebration of science and reason held on or around Feb. 12, the birthday anniversary of evolutionary biologist Charles Darwin" (International Darwin Day Foundation, 2014, para. 1). It is unlikely that The *International Darwin Day Foundation* membership is comprised of the weakest members of society, but the outspoken atheists, Richard Dawkins and Daniel C. Dennett are among its advisory board members (International Darwin Day Foundation).

Evolutionary Certitude

The study of evolution is characterized by a number of distinct, but overlapping levels of certitude (Stenson, 1984). Some aspects of evolutionary theory are factually indisputable. Other aspects of the evolutionary theory are reasonable conjectures that are generally accepted among scientists and others are untested hypotheses in need of further verification and study. Unlike the study within empirical disciplines, such as, chemistry or physics, evolutionary sciences are subject to difficulty in establishing certitude for the reason that the evolutionary disciplines, apart from biology, are effectively historical.

Paleontologists, for example, are continually interpreting their findings, as they seek to explain what happened to living things through the ages (Stenson, 1984). As researchers advance hypotheses to explain the fossil record, they are offering what they understand to be reasonable interpretations, which may or may not be verified through further research. Paleontological conclusions are then continually being revised, which accounts for the fact that the field is highly dynamic in nature. As a result, paleontologists often advance imaginative interpretations that are later overturned.

For example, early 20th century scientists took much greater liberty in describing ancient humans than do their contemporary counterparts (Stenson, 1984). Scientists a century ago used great imagination in describing their conception of the "caveman:" a hunched-over, hairy, dull creature that lacked language beyond grunting sounds. The notion of the barbaric caveman has been represented in virtually every media form over the last century and is now firmly established in the public consciousness.

More recently, based on the extant paleontological and archeological evidence, scientists have overturned the imaginative notion of the caveman as a rudimentary, dull-minded creature (Stenson, 1984). The fossil record simply offers no evidence to suggest the ancient man was hairy, unintelligent, or lacked speech. This unsupported notion of Paleolithic man was, however, advanced in many forms, as it was consistent with the "survival of the fittest" premise within Darwinism (Schonborn, 2008).

Biology is uniquely suited to the study of living organisms, including their morphology, physiology, anatomy, and distribution (Ayala, 2010; Behe, 2007). Since the release of Darwin's *Origin of Species* in 1859, biologists have not ceased in their efforts to confirm Darwin's evolutionary theory, which is contingent on genetic variation, through the process of random mutation and natural selection (Ayala, 2010; Goldschmidt, 1940; Gould, 1977; Kenney, 2013; Rohner et al., 2013). Notwithstanding the claims of modern biologists, as is illustrated in some detail above, thus far they have failed to confirm the cornerstone of Darwin's proposed evolutionary mechanism – gradualism (Gould & Rose, 2007; Schonborn, 2008; Schuster, 2008; Stark, 2003; Wiker, 2009).

Biology has, however, confirmed several aspects of microevolution, which is characterized by small-scale changes within a species, occurring over a short period of time (Ayala, 2010; Behe, 2007). But biologists have made much less progress in their attempts to confirm macroevolution (i.e., large-scale evolutionary changes to species, over geologic time, resulting in the vast variation of species (Behe, 2007; Gould & Rose, 2007). For example, biological science has very recently contributed to the negation of a long-standing, very prominent evolutionary hypothesis concerning the Neanderthal (Cameron & Groves, 2004).

Since its discovery in the early 19th century, the Neanderthal was long considered a credible missing link, but recent fossil, archeological, and significantly, molecular evidence, strongly suggests that the Neanderthal and *homo sapien* are different species that share several similar characteristics (Cameron & Groves, 2004). According to the molecular clock and fossil record, the Neanderthal first appeared approximately 500,000 years ago and lived in the colder regions of Europe during the Ice Age. Scientists do not currently contend that Neanderthal were particularly more suited to withstand cold conditions than were their *homo sapien* counterparts, so over time some other factor or condition pushed the two species farther apart, possibly cultural differences.

Molecular biologists have recently confirmed that Neanderthal mitochondrial DNA is significantly different from both modern humans and *homo sapien* who lived 40,000 years ago (Cameron & Groves, 2004). Approximately 30,000 years ago, the

European Neanderthal species suffered increased competition, increased mortality rates, and a decline in birthrates, which all contributed to their subsequent extinction. It is interesting that biological evidence has confirmed that between 40,000 and 60,000 years ago, a distinct species of Neanderthal arose in Asia and in the same period, *homo sapiens* arose in Australia. Significantly, biological evidence has confirmed that there are no close biological affinities between the Australian species, which are clearly *homo sapien*, and the European and Asian Neanderthal groups.

Recent scientific efforts concerning the nature of the long-extinct Neanderthal exemplify how the various scientific disciplines converge to form new hypotheses and revise others (Cameron & Groves, 2004). It is the case then that several distinct, but overlapping levels of certitude converge to form evolutionary hypotheses and establish theory (Stenson, 1984). Unfortunately, scientific magazines and other popular sources rarely, if ever, draw distinctions between the levels of certitude involved in the study of evolutionary theory (i.e., incontestable facts versus reasonable conjectures versus still untested hypotheses in need of further study). Apart from the biological sciences, the study of the evolution of life forms is effectively historical in nature, and as such, are unrepeatable events from the past that by nature are extremely difficult to empirically confirm.

Empirical science seeks to explain natural phenomena (Lindberg, 1992; Woods, 2005). Christian thinkers long speculated by what means God created the universe and everything it contains. Speculation concerning several important theological questions ultimately led to insights that served to form the Western understanding and worldview concerning God, creation, and nature.

Creation in the Christian Tradition

Christian thinkers had long speculated concerning the precise mode in which God created the universe (Spitzer, 2010). In the fourth-century, St. Augustine had proposed that it would not be unnatural, but natural to suppose that God should have used natural, original causes in the production of the human body (Wasmann, 1909). Traditional biblical exegesis maintains the long-standing Christian understanding that the natural laws were created and put in place by God, and therefore, it is reasonable to suppose that He would utilize their means in creation (Aquinas, 1261/1975; Augustine, 415/1982).

In the 13th century, St. Thomas Aquinas expressed agreement with Augustine in the third book of his *Summa Contra Gentiles*, wherein he discussed the execution of divine Providence by means of secondary causes (Aquinas, 1261/1975). Aquinas wrote: "divine operation does not exclude the operations of secondary causes…secondary causes are the executors of divine Providence," and thus, "it is appropriate that the execution of divine Providence be carried out by diverse levels of agents…Therefore, the perfection of divine Providence demands that there be intermediary causes as executors of it" (Aquinas, 1261/1975, p. 258-260). Aquinas taught that God's power is shown to be even greater as He chose to express His power and accomplish His ends through secondary causes (Aquinas, 1261/1975). In the 16th century, the Jesuit priest, Francisco Suarez, once again reiterated the ancient Christian understanding concerning the mode of creation and secondary causes: "God does not interfere directly with the natural order, where secondary causes suffice to produce the intended effect" (as cited in Wasmann, 1909, para. 5).

Thus, the Christian position regarding creation, since at least the time of Augustine in the fourth-century, has maintained that the generation of plant and animal life on earth, which scripture expressed in only a few short verses, would have filled billions of pages to even begin to describe (Wasmann, 1909). Thus, the ancient Christian understanding has long held that the opening phrase of the Old Testament: "In the beginning God created heaven and earth," could rightfully be understood as the title page to God's creative work.

As a scientific hypothesis, the theory of evolution is in accord with the historical Christian understanding of the cosmos, in that Scripture does not venture to describe what specific form the various species of plants and animals were created in (Wasmann, 1909). Thus, in response to those who read scripture literally, Augustine quipped: "One does not read in the Gospel that the Lord said: 'I will send you the Paraclete who will teach you about the course of the sun and moon.' For he willed to make them Christians, not mathematicians" (as cited in Catholic Answers, 2004, para. 12). The ancient Christian understanding of creation, in keeping with the early teachings of Augustine, Aquinas, Suarez, and many others, was again reiterated eighteen years after the publication of Darwin's *On the Origin of Species*. The 1877 statement on creation by the Jesuit biblical scholar, Fr. Joseph Knabenbauer, is worth citing in full:

> Considered in connection with the entire account of creation, the words of Genesis cited above proximately maintain nothing else than that the earth with all

> that it contains and bears, together with the plant and animal kingdoms, has not produced itself nor is the work of chance; but owes its existence to the power of God. However, in what particular manner the plant and animal kingdoms received their existence: whether all species were created simultaneously or only a few which were destined to give life to others: whether only one fruitful seed was placed on mother earth, which under the influence of natural causes developed into the first plants, and another infused into the waters gave birth to the first animals – all this the Book of Genesis leaves to our own investigation and to the revelations of science, if indeed science is able at all to give a final and unquestionable decision. In other words, the article of faith contained in Genesis remains firm and intact even if one explains the manner in which the different species originated according to the principle of the theory of evolution (as cited in Hess & Allen, 2008, p. 79).

Dupree (1986) examined the 19th century Protestant reaction to Darwin's theory of evolution and found a wide diversity of opinion among Protestant scientists and clergy (Hess & Allen, 2008). Nonetheless, it is the case that mainstream Protestant churches adopted a similar position to that of the Catholic Church, as expressed above. However, some Protestant Christians outside of the mainstream denominations came to regard themselves as the guardians of orthodoxy and following the publication of the *Origin of Species*, began to organize against Darwinism, and significantly, against any suggestion of the evolution of life forms (Noll, 2002).

19th-century Origins of Fundamentalist Christianity

Fundamentalist Christianity is a term often used to depict a particular segment of Protestant Christianity that has its roots in 19th century British and American theology (Patheos, 2012). The fundamentalist movement emerged as a synthesis or "allegiance between two newly-formulated 19th century theologies, dispensationalism and the Princeton Theology" (as cited in Patheos, 2012, The Approaches of Others section, para. 3). Dispensational theology proposes that the biblical record of history should be understood in terms of stages or dispensations and that several important prophesies of future events are foretold in the New Testament, which describe God's divine plan in great detail (Noll, 2002; Patheos, 2012).

Dispensationalism was first professed by a 19th century Anglican priest, John Nelson Darby (1800-1882). Darby eventually left Anglicanism and established his own following among a small group of Plymouth Brethren in England and Ireland during the 1820s. The doctrine that Christ must return to rapture the elect out of the world before the final dispensation (i.e., "premillennialism") was first professed by Darby and is now a defining doctrine of fundamentalist Christianity (Sandeen, 1967).

From the time of their origins in the early 19th century, fundamentalist Christians saw themselves as the sole surviving remnant of believers who professed the true Christian faith (Patheos, 2012). They believed that through Darby they had recaptured the true Gospel message, which had been lost within the first few centuries of Christianity. The traditional Protestant denominations rejected Darby's premillennialist doctrine, as a novel interpretation of scripture and fundamentalist Christians reacted by labeling as liberal any Protestant group that did not accept their doctrines. The mainstream Protestant denominations rejected the fundamentalists' premillennialist doctrine and resented the fundamentalists' fervent opposition to the liberal theology taught in prominent Protestant seminaries of the time. As a result of these differences, a noticeable militancy arose that permeated fundamentalist Christianity (Sandeen, as cited in Patheos, 2012).

In the late 19th century, a group of Calvinists, who were connected to the Princeton theological seminary, became interested in the dispensationalists premillennialist doctrine (Patheos, 2012). In 1878, the Princeton Calvinists assembled for the First International Prophetic Conference for the purpose of exploring the dispensationalists prophetic themes, including premillennialism. The conference of 1878 initiated a long period of collaboration between dispensationalists and Princeton oriented Calvinists (Sandeen, 1967).

Innovative Biblical Exegesis

Christians had, from the beginning, understood the Bible to be the inspired word of God (Noll, 1994). Traditional norms of Christian biblical exegesis accepted by Catholics and generally accepted by the mainstream Protestant denominations maintains: (a) the Holy Spirit inspired the authors of sacred scripture; (b) scripture teaches God's truth without error; (c) an awareness of the cultural norms and conditions of their time, as well as the literary genres common to the time, must be considered so as to discover the author's intention. "For the fact is that truth is differently presented and expressed in the various types of historical writing, in prophetical and poetical texts, and in other forms of literary expression" (Catechism, 1995, 107, 110).

But in the late 19th century, that long-held understanding of biblical exegesis was denounced by four Princeton Calvinists and supplanted for a new standard (Noll, 2002; Patheos, 2012; Stark, 2003). The Princeton Calvinist theologians, Charles Hodge, A.A. Hodge, B.B. Warfield, and J.G. Machen, also believed the Bible to be the inspired word of God, but they went a step further and advanced an innovation in biblical exegesis known as the doctrine of inerrancy (Skehan & Nelson, 2000; Walsh, 1915).

The term "inerrancy" had been used in biblical exegesis for many centuries, but the Princeton theologians expanded and redefined inerrancy to mean every word of the Bible is true in every sense (Skehan & Nelson, 2000). The doctrine of inerrancy came to denote a set of convictions: "1) the Bible is verbally inspired; 2) inerrant in its every reference, statistic, and quotation; and 3) as written down on the original autographs" (Sandeen, 1967, as cited in Patheos, 2012, The Role of Princeton Theology section, para. 2). Fundamentalist Christianity adopted this hyper-literal reading of scripture that is strikingly similar to how Muslims read, understand, and interpret the Qur'an (Reilly, 2010), which accounts for the fact that fundamentalist Muslims and fundamentalist Christians are allies in their anti-evolution efforts (Rehman, 2011).

In his *Systematic Theology*, Charles Hodge explained how biblical inerrancy is to be understood and applied by the fundamentalist Christian:

> The Bible is to the theologian what nature is to the man of science. It is his storehouse of facts; and his method of ascertaining what the Bible teaches, is the

> same as that which the natural philosopher adopts to ascertain what nature teaches… The duty of the Christian theologian is to ascertain, collect, and combined all the facts which God has revealed concerning himself and our relation to him. These facts are all in the Bible (as cited in Noll, 2002, p. 267).

In redefining the term "inerrant," the Princeton Calvinists supplanted 2,000 years of exegetical standards for a hyper-literal interpretative methodology (Sandeen, 1967; Patheos, 2012), which abandoned the custom of interpreting some scriptural passages allegorically, symbolically, or figuratively – at least those passages which seem to contradict the fundamentalist position (Patheos, 2012; Sandeen, 1967). A hyper-literal exegesis was necessary to defend the fundamentalist Christian doctrines of dispensationalism and premillennialism, both of which can only be understood within the framework of a strict, literal interpretation of scripture. "According to dispensationalism, history is controlled by supernatural forces; if read literally – hence the importance of inerrancy – the Bible (particularly the books of Daniel and Revelation) provides a sure guide to the past, present, and future of human history" (Trollinger, 2004, p. 346). Thus, from that time forward anything that threatened biblical literalism was denounced as liberal or even heretical.

With an eagerness to anticipate the end of the world (Sandeen, 1967) and bound to the idea that everything written in sacred scripture is to be interpreted literally (Stark, 2003), premillennialists became the most uncompromising foes of the theory of evolution (Numbers, 2002). Consequently, the premillennialists had no tolerance for scientists, who, as expressed by the preacher Dwight L. Moody (1837-99), ‘dug up old carcasses...to make them testify against God’" (p. 279).

A hyper-literal interpretation of scripture was an essential precondition in support of the doctrines of dispensationalism and premillennialism (Patheos, 2012). Thus, three elements united to form what came to be known as fundamentalist Christianity: (1) a hyper-literal reading of scripture; (2) dispensationalism; and (3) premillennialism. “The view that most fundamentalists had about the origins of their beliefs being consistent with the past is flawed” and “in other words, fundamentalists innovated several theological ideas in support of their dispensationalist premillennialist theology that had not been held in the past” (Sandeen, 1967, as cited in Patheos, 2012, The Allegiance section, para. 2).

By the beginning of the 20th century, dispensationalists, now further defined by their doctrine of inerrancy, sought to distance themselves further from what they considered liberal mainline Protestant denominations (Trollinger, 2004). In 1909, two wealthy Protestant laymen donated the necessary funds to produce a work, which would denounce what they judged to be liberal theology and redefine the fundamentals of Christian belief. Between 1910 and 1915 a group of fundamentalist ministers produced a twelve-volume compilation of essays in defense of their understanding of Protestant orthodoxy. They expounded on what they judged to be the fundamentals of Christianity and further defined the concept of biblical inerrancy with its steadfast adherence to a literal reading of scripture. Their twelve-volume work entitled, *The Fundamentals: A Testimony to the Truth*, provided the framework of what came to be known as fundamentalist Christianity.

Fundamentalist Objections to Science

The fundamentalist Christians' literal reading of scripture triggers conclusions that are entirely incompatible with the claims of modern science (Skehan & Nelson, 2000). By far, the most well-known conflict concerns the fundamentalist Christians' denunciation of and opposition to the theory of evolution (Larson, 2003; NCSE, 2012), but their resistance to the claims of modern science are not confined to biological evolution. Their literal reading of the creation accounts in the Book of Genesis, along with the various genealogies recorded in scripture, have caused fundamentalist Christians to conclude that the earth and universe are very young – 10,000 years or less (Creationist, 2012; Marrapodi, 2012). Thus, fundamentalist Christian beliefs fall counter to the claims of several scientific disciplines that have independently concluded the earth and universe are much, much older. The result is that independent scientific disciplines, such as, anthropology, archeology, astrophysics, biology, earth science, geology, and physics, have all reached scientific conclusions that call into questions various fundamentalist Christian claims (Russell, 2002; Skehan & Nelson, 2000).

Beginning early in the 20th century, fundamentalist Christians, who held to a young earth and universe – also known as creationists – began to publically object to the teaching evolution in public schools (Larson, 2002; Skehan & Nelson, 2000). The public schools became the battleground in the fight over evolution and have remained so to the present. Darwin's theory of evolution (i.e., any theory of evolution) is simply incompatible with Biblical literalism and the result has been a conflict that has not abated for more than a century (Larson, 2003).

Creationism Defined

The word “creationism” has several meanings (Skehan & Nelson, 2000). In the broadest sense, which Christians, Jews, Muslims, and others, such as the Navaho, believe, creationism denotes the idea that a supernatural power or even powers created the universe. “Creationism” is used in a much narrower sense by some contemporary fundamentalist Christians, who implement a hyper-literal interpretation of scripture (Sandeen, 1967). In this sense, creationism has come to mean “special creation”, which denotes “the doctrine that the universe and all that is in it was created by God in essentially its present form, at one time” (Skehan & Nelson, 2000, Creationism section, para. 1).

Most commonly, the doctrine of *special creation* asserts: (1) the earth and universe are very young – less than 10,000 years old; (2) created organic life forms appeared suddenly and have not changed; and (3) all organic life forms were designed for a certain function or purpose (Skehan & Nelson, 2000). Other evangelical Christians interpret the creation account in Genesis much differently, such as a belief in the Gap Theory, which suggests that billions of years may have transpired between events described in Genesis 1:1 and 1:2, and the Day Age Theory, which understands the biblical days of creation as epochs of time. Fundamentalists who advance *special creation*, denounce the Gap and Day Age theories as liberal “because they believe that such accommodation is inevitably followed by acceptance of the evolutionary system” (Fundamentalism and Fundamentalist Religion section, para. 4).

Creation Science

Creation science represents the means through which creationists seek to support the concept of *special creation* through scientific means (Skehan & Nelson, 2000). Some Christian groups use the terms “creation science” interchangeably with “intelligent design theory”, “abrupt appearance theory”, and “initial complexity theory” (Creationism section, para. 3). Unlike the methodologies characteristic of the empirical sciences, *special creation* claims fail to provide a basis for solving the complexities of nature related to old and new problems. Moreover, a glaring disparity between empirical science and creation science is the conspicuous absence of a methodology within the latter. As a general rule, creation science does not seek to acquire new information concerning the natural world. That is, creation science is not characterized as a diligent quest for new knowledge and discovery through investigation of theory, experiment, and observation related to the complexities of natural phenomena. Rather, creation science is characterized by the quest to discredit any scientific claims that fall contrary to their theological doctrine (i.e., young universe and earth, sudden appearance of all organic life forms that have remained essentially stable). Creation science seeks to discover anomalies among any scientific theories or empirical facts that are contrary to the doctrine of *special creation*, but rarely, if ever, investigate natural phenomena or develop new, useful scientific theories. Thus, empirical claims are deemed acceptable only when they conform to the doctrine of *special creation* (Skehan & Nelson, 2000).

The difficulty the doctrine of *special creation* imposes on science is that science is limited to – can only employ – natural explanations to describe the natural order

(Skehan & Nelson, 2000; Spitzer, 2010). Supernatural explanations, including particular religious doctrines, are simply outside the realm of science. Empirical science is simply not capable of answering the question of whether or not supernatural influence played a part in bringing about the universe. The role of science is to discover natural explanations for natural phenomena – not seek to support or discredit any particular theological position.

Scientists investigate nature, whereas, philosophers and theologians contemplate and make judgments on spiritual matters (Skehan & Nelson, 2000; Spitzer, 2010). Empirical science, philosophy, and theology are distinct disciplines. Although the conclusions of one discipline may have implications for another, each discipline is bound by their distinct methodological norms. Creation science represents an attempt to bolster a particular theological position through interpreting natural phenomena in light of that position. Likewise, when scientists, particularly Darwinists, have left their domain of expertise and ventured into the realm of theology, the results have been ruinous to their cause as well (Dawkins, 2006; Harris, 2004). The same is true for theologians who have ventured beyond the limits of their expertise into the scientific realm (Stark, 2003).

"Creation" is a religious term denoting God's creative action, whereas, "science" is concerned with the investigation of natural phenomena (Skehan & Nelson, 2000). As a result, the term "creation science is an oxymoron because it involves contradictory claims" (Religious Science? Scientific Religion? section, para. 1). Professor Emeritus in the Divinity School of the University of Chicago, Langdon Gilkey, observed: “Religious discourse in Western religions refers to God, a transcendent being, one who is the source and ground of creaturely beings, and, therefore, not part of the creaturely system" and added "because God is referred to as the origin of the system of nature, he cannot be part of nature" (as cited in Skehan & Nelson, 2000, Religious Science? Scientific Religion? section, para. 2 and 3). The term "creation science" may best be understood as the creationist's view of empirical science, as opposed to a distinct type or approach to science.

The creationist, Steve Golden, unwittingly revealed the underlying incoherence of the creationist's approach to science:

> While we at Answers in Genesis acknowledge that one's view on the origin of man is not a salvation issue, we do say that it is an authority issue. Believing in theistic evolution as a Christian means you reject the authority of God's Word, because the creation account in Genesis teaches a literal six-day creation (Genesis 1). Even the idea of "theistic evolution" is problematic, because evolutionary ideas were created to explain a world without God. If we approach Scripture from the standpoint that it teaches absolute truth, then every branch of science must be interpreted in light of biblical teaching — not the other way around (as cited in Mahta, 2012, para. 3).

Golden unintentionally exposed the logical fallacy inherent in creation science: The scientific method seeks facts and draws conclusions based on those facts; creation science begins with a conclusion drawn from a particular interpretation of the Bible, then interprets existing facts and sometimes seeks to find new facts to support the preexistent conclusion. As a result, creation science is devoid of or independent of the scientific methodology that denotes empirical science (Creationist, 2012).

Because creation science begins with conclusions drawn from the fundamentalist Christian interpretation of scripture and then seeks facts in support of those conclusions, they often arrive at extremely implausible – even odd – conclusions. For example, the organization Creation Moments, which stated that they believe the Bible is objectively infallible and inerrant, proposed that the ancient Egyptians flew sophisticated gliders and may have flown powered aircraft (Creation Moments, 2014). Commenting on what appears to be a wooden carving of a bird discovered by archeologists in Egypt, Creation Moments reported: "This 2,200 year old model airplane had wings that angle slightly downward at the ends—exactly the same improved wing design that was first used in modern times on the supersonic Concorde" (para. 4). Thus, they proudly exclaim that they have uncovered another fact that disproves evolution: "now it appears that we creationists were right – we have always been smart enough to do something about our interest in flight as well" (para. 5). In other words, in an ill-fated attempt to discredit the concept of human evolution, the people at Creation Moments proposed that Egyptians were intelligent enough and sophisticated enough to develop aircraft.

Twentieth-century Fundamentalist Christianity

Strict creationist views engendered an anti-evolution movement, which grew very rapidly among fundamentalist Christians in the United States (Numbers, 2002). Creationists surmised that their best option in opposing evolution was to seek the adoption by public schools of a curriculum that taught scientific creationism, as an alternative to biological evolution. The difficulty creationists were facing, however, was a scarcity of scientific experts. "Twenty years after the publication of Charles Darwin's (1809–82) *Origin of Species* in 1859, *special creationists* could only count two working naturalists in North America, John William Dawson (1820–99) of Montréal and Arnold Guyot (1807-84) of Princeton" (pp. 277–278). In terms of science experts, the state of affairs in Europe was essentially the same for the creationists cause. The scientific community had adopted Darwin's theory (Bowler, 2002) and Protestant churchmen on both sides of the Atlantic had done the same, leaving the newly formed fundamentalists as the sole defenders of creationism and biblical literalism.

The situation creationists found themselves in was aptly described in Numbers (2002):

> The antievolutionists liked to wrap themselves in the authority of science, but, unfortunately for them, they could claim few legitimate scientists of their own: a couple of self-made men of science, one or two physicians, and a handful of teachers who, as one evolutionist described them, were 'trying to hold down, not a chair, but a whole settee, of 'Natural Science' in some little institution' (p. 281).

An alarmed premillennialist declared in 1889, "when these vague speculations, scattered to the four winds by the million-tongued press, are caught up by ignorant and untrained men, it is time for earnest Christian men to call a halt" (as cited in Numbers, 2002, p. 280). *Special creationists* undertook a discernible shift in strategy, in which the leading apologists for *special creation* sought to move from an openly biblical defense of their views to one based on scientific claims (Numbers, 2002). By the late 19th century, after the scientific community had a few decades to investigate Darwin's theory, some scientists began to question particular aspects of his ideas. In particular, some scientists questioned whether or not Darwin's theory of natural selection could account for the origin of species, which the title of his book had claimed. Scientists published books with such titles as *The Collapse of Evolution* and *At the Deathbed of Darwinism*, which *special creationists* misinterpreted as the scientific community's utter abandonment of evolution as a theory, as opposed to specific criticisms of Darwin's claim to have discovered the origin of species. Creationists construed specific objections put forth by some members of the scientific community to natural selection as the evolutionary mechanism by which evolution occurs, as infallible evidence against the theory of evolution as a whole.

In the 1920's, the Presbyterian layman and three-time Democratic candidate for the presidency of the United States, William Jennings Bryan (1860–1925) led what became a popular crusade against teaching the theory of evolution in public schools (Larson, 2003). In 1922, Bryan learned that the state of Kentucky was seeking to ban the teaching of evolution in its public schools (Numbers, 2002). Bryan predicted, "the movement will sweep the country and we will drive Darwinism from our schools" (as cited in Numbers, 2002, p. 280). Although his prediction was overly optimistic, he was correct that a wave of anti-evolution opposition was soon to arrive, particularly in the southern United States. Tennessee, Mississippi, and Arkansas each passed laws which forbade the teaching of evolution in public schools. The state of Oklahoma followed suit by prohibiting the use of evolutionary textbooks and Florida condemned the teaching of

Darwin's theory. Bryan's staunchest supporters were overwhelmingly from the still largely rural South, which one fundamentalist Christian journal described as, "the last stronghold of orthodoxy on the North American continent" where the "masses of the people in all denominations 'believe the Bible from lid to lid'" (as cited in Numbers, 2002, p. 281).

Leadership of the anti-evolution movement came from individuals like William Jennings Bryan and organizations like the World's Christian Fundamentals Association, which was a premillennialist body founded in 1919 by William Bell Riley (1861–1947) (Numbers, 2002). Riley, a pastor of the First Baptist Church in Minneapolis, became an active anti-evolutionist when he, to his great surprise, discovered that the theory of evolution was being taught at the University of Minnesota. Bryan and Riley set out "to drive every evolutionist from the public-school payroll" (p. 281).

Bryan and Riley joined forces with fellow anti-evolution fundamentalists Harry Rimmer (1890–1952) and George McCready Price (1870–1963), in an effort to develop a scientific case against evolution that was consistent with their hyper-literal interpretation of scripture (Numbers, 2002). Rimmer was a Presbyterian minister and self-styled "research scientist," who had obtained his limited exposure to science during a semester or two at Hahnemann Medical College in San Francisco. After which, he attended Whittier College for a short time and then studied one or two years at the Bible Institute of Los Angeles, which qualified him for full-time evangelistic work. In about 1919, Rimmer set up a small laboratory at the rear of his house in Los Angeles, where he conducted experiments in embryology and related sciences. One or two years later he set up the Research Science Bureau for the express purpose of proving "through findings in biology, paleontology, and anthropology that science and the literal Bible were not contradictory" (as cited in Numbers, 2002, p. 282). Rimmer, who comprised the entire bureau staff, sold memberships in the Research Science Bureau to finance anthropological field trips in the western United States (Numbers, 2002).

By the late 1920s, the Research Science Bureau was dormant, so Rimmer went to work as the field secretary at Riley's World's Christian Fundamentals Association (Numbers, 2002). Without any recognized credentials, Rimmer still portrayed himself as a scientist, while delivering thousands of lectures to mostly student groups, wherein he sought to articulate the scientific exactitude of the Bible. Rimmer masqueraded as a scientist for several decades in the cause of fundamentalist Christianity and *special creation*.

George McCready Price was, like his counterpart Rimmer, a flamboyant character and pseudo-scientist, who advanced anti-evolution arguments in light of his Seventh-day Adventist beliefs (Numbers, 2002). He attended a Seventh Day Adventist college in Michigan and then transferred to the provincial normal school in his native New Brunswick, where he successfully completed a teacher training course. At the turn of the 20th century, Price was the principal of a small high school in an isolated part of eastern Canada and one of his only companions was a local physician and evolutionist. Price later admitted that during several of their many conversations, his friend almost convinced him to accept the theory of evolution, but each time he was saved through personal prayer and his recommitment to the works of the Seventh-day Adventist prophetess, Ellen G. White (1827–1915). White claimed divine inspiration for her assertion that the entire fossil record can be explained in light of Noah's Flood. Ultimately, Price vowed to dedicate his entire life to the promotion of strict creationism.

In 1906, while employed as a handyman at the Adventist sanitarium in southern California, Price published a short volume entitled *Illogical Geology: The Weakest Point in the Evolution Theory*, wherein he offered 1,000 dollars "to anyone who will, in the face of the facts here presented, show me how to prove that one kind of fossil is older than another" (as cited in Numbers, 2002, p. 282). Not surprisingly, he never had to pay the cash prize because he was the arbiter of the rules and never accepted any evidence to the contrary. During the next 15 years, Price was employed as a "scientist" at several different Seventh-day Adventist schools and published six more books attacking evolution, normally focusing on its geological foundation. Conspicuously unencumbered by modesty, Price described his 1923 book *The New Geology*, as his, "great law of comfortable stratigraphic sequences...by all odds the most important law ever formulated with reference to the order in which the strata occur" and his new law stated that "any kind of fossiliferous beds whatever, 'younger' or 'old,' may be found occurring comfortably on any other fossiliferous beds, 'older' or 'younger'" (as cited in Numbers, 2002, p. 283).

Price claimed he found, what he called "deceptive conformities," where strata seem to be missing, and "thrust faults," where strata are apparently out of order (Numbers, 2002). To Price, this proved that there was no natural order to the fossil record within the strata and he attributed this to Noah's Flood. Predictably, the scientific community ridiculed Price and his "scientific" findings. Not surprisingly, the fundamentalist movement interpreted the science establishment's outright rejection of Price's work as clear evidence his claims were valid. By the mid-1920s, the Seventh Day Adventist, Price, was held in such high esteem among fundamentalists that the editor of *Science* could refer to him as, "the principal scientific authority of the fundamentalists" (as cited in Numbers, 2002, p. 283).

1920s Anti-Evolution Movement

In the spring of 1925, a high school teacher in Dayton, Tennessee, John Thomas Scopes (1900–70), admitted to violating the state of Tennessee's recently passed law that banned the teaching of human evolution in public schools (Numbers, 2002). William Jennings Bryan was enlisted to assist the prosecution in the trial, which focused international attention on the anti-evolution crusade. The court in Dayton ultimately found Scopes guilty of teaching evolution, but creationists found little solace in the victory because the end result for the creationist's cause was one of ridicule within the national press. The majority of the negative press fell on Bryan and the taxing ordeal probably contributed to his death within a few days of the end of the trial. However, the anti-evolutionists pressed on and subsequently won victories in Mississippi in 1926 and then in Arkansas in 1928, but by the end of the decade the successes attributed to their legislative campaign waned.

The creationist's legislative successes diminished, so they then changed their strategy (Numbers, 2002). They shifted their efforts to the local level, where they sought to influence local school boards to disallow any textbooks containing evolutionary material, pressure rural and urban teachers to give up teaching evolution, purge schools and public libraries of evolutionary texts, and apply pressure to textbook publishers. Their new strategy was very successful and also garnered much less attention than their previous legislative efforts. As a result of their new strategy, evolution "virtually disappeared from high-school texts, and for years many American teachers feared being identified as evolutionists" (p. 283). Creationists turned from attempting to convert the world to their position and began organizing their own societies and publishing their own journals.

1960s and Beyond Creationist Revival

The 1960s gave rise to a creationist revival that was begun by an engineer from Texas, Henry M. Morris (1918–2006), and a theologian of the Grace Brethren denomination, John C. Whitcomb Jr. (1924–) (Numbers, 2002). Raised a nominal Southern Baptist, Morris believed in creationism, but as a youth he had lost interest in religion and drifted into evolutionism. Following his graduation from college, he thoroughly studied the Bible, regained his faith, and reevaluated his belief in evolution. He ultimately became convinced that creation had taken place in six literal days because the Bible was clear on that point and "God doesn't lie" (as cited in Numbers, 2002, p. 284). Morris and Whitcomb began collaborating in the 1950s on a defense of the Flood account, which was essentially a repackaging of George McCready Price's 1923 book *New Geology*. By the time they had finished their work, Morris had earned a Ph.D. in hydraulic engineering from the University of Minnesota and Whitcomb was teaching Old Testament studies at Grace Theological Seminary in Indiana.

Morris and Whitcomb released *The Genesis Flood* in 1961 (Numbers, 2002). They, of course, began their work by testifying to their belief in "the verbal inerrancy of Scripture," (as cited in Numbers, 2002, p. 284), as devised by the late 19th century Princeton Calvinists, Charles Hodge, A.A. Hodge, B.B. Warfield, and J.G. Machen, during their 1878 First International Prophetic Conference (Patheos, 2012). In *The Genesis Flood,* Morris and Whitcomb argued for: (1) a young universe; (2) a Fall that caused the second law of thermodynamics; and (3) a Flood that covered the entire earth and deposited the majority of the geological strata in only one year (Numbers, 2002). They confidently declared that in light of their work, "the last refuge of the case for evolution immediately vanishes away, and the record of the rocks becomes a tremendous witness…to the holiness and justice and power of the living God of Creation" (as cited in Numbers, 2002, p. 284).

Creationist hailed *The Genesis Flood* as a great scientific work that finally set the record straight and others denounced it as a travesty on the discipline of geology (Numbers, 2002). For their part, Morris and Whitcomb generally refused to respond to their critics within the scientific community. They reasoned, that "the real issue is not the correctness of the interpretation of various details of the geological data, but simply what God has revealed in his Word concerning these matters" (as cited in Numbers, 2002, p. 285).

For the creationist movement, *The Genesis Flood* prompted tremendous energy within the movement and a renaissance of sorts for what had originated as an explanation of the Flood geology originally proposed by the Seventh Day Adventist prophetess, Ellen

G. White (Numbers, 2002). Creationists were energized by *The Genesis Flood* and began to organize. In 1963 the Creation Research Society (CRS) was founded by Walter E. Lammerts (1904–96), a Missouri Synod Lutheran who possessed a doctorate in genetics from the University of California. Several years earlier, Lammerts had read Price's *New Geology* and worked with Price at a local creationist society. Disenchanted by some evangelical's acceptance of evolution, in the 1960s he began a correspondence with Morris and eight other strict creationists, who came to be known as "the team of ten" (p. 285). In 1963, the group met at the home of a team member in Midland, Michigan and formed the (CRS). Five of the founding CRS members possessed doctorates in biology; one held a Ph.D. degree in biochemistry, and the seventh held a master's degree in biology.

CRS projects included expeditions in search of Noah's Ark, studies of fossilized human footprints, investigations of pollen grains found outside of the predicted evolutionary sequence, experiments on plants that possessed radiation- produced mutations, and theoretical studies in physics proposing a recent origin of the earth (Numbers, 2002). In comparison to the previous history of the creationist's cause, it was a promising beginning.

Nonetheless, the creationist revival of the 1960s attracted little public attention until the end of the decade when fundamentalists learned the California State Board of Education was requiring federally funded Biological Sciences Curriculum Study texts that included evolutionary principles. Two determined southern California women, Nell J. Segraves and Jean E. Sumrall were convinced that they "were entitled to protect our children from the influence of beliefs that would be offensive to our religious beliefs" (as cited in Numbers, 2002, p. 286). Segraves and Sumrall persuaded the California State Board of Education to grant creationists equal space in textbooks.

In the 1970s, Segraves and her son Kelly made an effort to establish a Creation Science Research Center (CSRC) that was affiliated with the Christian Heritage College of San Diego (Numbers, 2002). The CSRC objective was to prepare creationist literature that would be deemed suitable for use in the public schools. But by 1972, Nell Segraves and her son Kelly had disagreements concerning CSRC goals. They separated from the college and subsequently dissolved the CSRC.

In the 1970s, creationists saw the need to change their strategy once again (Numbers, 2002). In the 1920s creationists had sought to outlaw evolution through legislative action. They then changed their focus and concentrated their efforts on the local level. In the 1970s, they began to fight for equal time and space by ceasing to appeal to the authority of the Bible and consciously downplaying the creation account in the Book of Genesis. They instead began to promote what they termed "scientific creationism" (p. 286). Creationists began to petition public schools to teach "only the scientific aspects of creationism," (p. 286) which, in practice, meant focusing on evidence of a recent worldwide catastrophe and on arguments against evolution, but leaving out all references to a literal six-day Creation and Noah's Ark. In 1974, the Institute of Creation Research (ICR) published a textbook entitled, *Scientific Creationism*, which was released in two editions. The public school edition contained no references to the Bible and the

Christian school edition included a chapter entitled "Creation According to Scripture" (as cited in Numbers, 2002, p. 287).

Creationists had changed their tactics and were by now advancing "creation science" or the Flood-geology model and were initially very effective at making inroads in public schools, particularly in their traditional stronghold, the Southern United States (Numbers, 2002). Both Arkansas and Louisiana's state legislatures and various school boards adopted the idea of teaching both creation science and evolutionary principles in classrooms. However, in *McLean vs. Arkansas* (1982), a federal judge struck down the Arkansas law, as unconstitutional, which was mandating a "balanced treatment" of creation and evolution in public schools (p. 287). The District court ruled that Creation scientists:

> … cannot properly describe the methodology used as scientific, if they start with a conclusion and refuse to change it regardless of the evidence developed during the course of the investigation (as cited in Scott, 2008, para. 10).

The lower court's decision was upheld by the United States Supreme Court five years later. Still, evidence of the effectiveness of the creationist's new strategy was demonstrated in a 1980 informal poll of American school board members, which showed that only 25% favored teaching evolution exclusively (Numbers, 2002).

The creationist revival initiated by Whitcomb and Morris in the 1960s, was highly successful insofar as it successfully elevated strict, literal six-day *special creationism* to a position of virtual orthodoxy among fundamentalists, influenced state governments, local school boards, and public opinion (Numbers, 2002). Whereas, the anti-evolution crusade of the 1920s was mostly confined to North America, the revival of the 1960s had a global influence. Creationist literature was distributed and new creationist organizations were founded in Great Britain, the Netherlands, Australia, New Zealand, Asia, and South America. By 1980, Morris's books alone were available in ten languages, including Chinese, Czech, Dutch, French, German, Japanese, Korean, Portuguese, Russian, and Spanish. As a result, strict creationism, which requires a hyper-literal interpretation of scripture, had ventured beyond the United States borders and become an international phenomenon (Numbers, 2002).

Uncomfortable Allies

The concept of *special creation* was first devised in the late 19th century by the Seventh Day Adventist prophetess, Ellen G. White, within her writings on Flood geology (Numbers, 2002). *Special creation* was then popularized with the 1923 release of the *New Geology*, written by White's disciple, George McCready Price (Numbers, 2002). Also in the late 19th century, fundamentalist Christians formulated the concept of biblical inerrancy (i.e., a hyper-literal interpretation of scripture) and within a few decades adopted *special creation* as a defining doctrine. However, it wasn't until the 1961 release of *The Genesis Flood* by Morris and Whitcomb that *special creation* gained international status (Numbers, 2002).

One seemingly unanticipated consequence of the creationist's international campaign is that *special creation* has been enthusiastically embraced by fundamentalist Muslims, who are doing their part in advancing *special creation* on an international basis (Ham, 2004). So much so that Britain's Secretary of State for Education, Michael Gove, candidly stated: “Islam is far and away the most important disseminator of creationism in the modern world” (Thompson, 2012, para. 6).

The creationist movement in Great Britain is persistent, uncompromising, and making significant gains within public education (Vasagar, 2012). Although fundamentalist Christians have a presence in the struggle, they are not leading the effort – devout Muslims are at the forefront of the creationist movement in England. Fundamentalist Muslim creationists maintain a presence throughout Europe. For example, a richly illustrated creationist textbook, *Atlas of Creation*, was published in Turkey and in 2007 free copies of the book were circulated throughout France’s public schools. In 2011, the book publisher, Harun Yahya, toured schools in France, wherein he denounced evolution and advanced creation “science” (Heneghan, 2011).

Islamic efforts to promote creationism in public schools within the United States are also on the rise (Rehman, 2011). Curiously, fundamentalist Christian creationists are troubled by the fact that fundamentalist Muslims interpret Old Testament scripture in the same way they do and have not yet formulated a practical response or partnership. A recent article by the *special creation* organization, Answers in Genesis, expressed the fundamentalist Christian’s dilemma. They are pleased that fundamentalist Muslims are advancing creationism, but very uncomfortable with the idea that their uninvited allies in the anti-evolution campaign are of the Islamic faith (Answers in Genesis, 2010).

In 2004, Ken Ham, the founder of Answers in Genesis, which is arguably the most prominent proponent of creation science in the United States, wrote:

> Many might be surprised that I would turn down an invitation to speak to a group of Muslims. But I don't want to be *any* part of their creation evangelism…Imagine my shock when I discovered that some Muslim leaders were using their own form of "creation evangelism" to convert people to Islam (Ham, 2004, para. 1).

Notwithstanding the fundamentalist Christians' uneasiness toward their Islamic associates in the struggle to promote creation science in public schools, while simultaneously rejecting the vast majority of findings produced by modern empirical science, the fact is that both Christian and Muslim fundamentalists employ the same hyper-literal interpretative approach to the Pentateuch (i.e., the first five books of the Old Testament) (Reilly, 2010). Fundamentalist Muslims use the same exegetical method in interpreting both the Pentateuch and the Qur'an, and as is the case with fundamentalist Christians, many fundamentalist Muslims interpret "days" in Genesis, as literal 24-hour periods of time (Heneghan, 2011).

Muslim creationists denounce evolution because they, like their fundamentalist Christian counterparts, believe that Adam, Eve, and all living creatures were created within the first six-days (i.e., twenty-four hour periods) without any need to evolve (Heneghan, 2011). However, other Muslim creationists differ with their fundamentalist Christian counterparts in their acceptance of current research concerning the age of the universe and earth because they interpret "days" in Genesis in an allegoric sense (para. 9).

Mohammed revealed his revelation, described in the Qur'an, at the beginning of the seventh-century (Reilly, 2010), which was in the midst of the Christian Patristic period (Pohle, 1912). The Christian Patristic period is precisely when the Early Church Fathers authored numerous works concerning the various layers of truth conveyed in scripture, (i.e., literal, allegorical, mystical, spiritual) (Jurgens, 1970). Hence, the long-standing Christian interpretive method elucidated by such figures as Origen (185-253), St. Basil (329–379), St. Jerome (340–420), St. John Chrysostom (347–407), St. Augustine, and later St. Gregory the Great (540–604) (Maas, 1909), was certain to influence the Muslim understanding of scriptural exegesis. The timing of Mohammed's revelation may account for the allegorical interpretation held by some Muslims, wherein "days" signifies epochs of time (Heneghan, 2011, para. 9).

Controversy in Popular Culture

Special creationists do not limit their crusading to the educational arena. They also seek to disseminate their point of view in the popular culture. For example, the 2014 release of the motion picture *Noah* garnered extensive criticism from fundamentalist Christian creationists because the movie told the story of Noah's Ark using some allegory and symbolism, in lieu of a strictly literal retelling (Rameau, 2014). When asked if the movie *Noah* could at least have value as a conversation starter with non-believers, *special creationist* and founder of Answers in Genesis, Ken Ham, responded, "the problems are such that the film could be counterproductive for non-Christians to watch" (para. 10).

Fundamentalist Christian creationist objections to the film *Noah* did not go unnoticed. In response to the controversy surrounding the film, Paramount Pictures added a disclaimer to their marketing material informing prospective viewers that "artistic license has been taken" in retelling the story (Associated Press, 2014, para. 2). Fundamentalist Muslim creationists also voiced their objections to the film. The director of media content for the National Media Center in the United Arab Emirates, Juma Al-Leem, stated: "There are scenes that contradict Islam and the Bible, so we decided not to show it" (para. 4). Muslim creationist objections were effective to the point that the movie was banned in several Arab nations, including: The United Arab Emirates, Qatar, Bahrain, and several other Muslim nations were expected to follow in the banning of the film (Associated Press, 2014).

Another contemporary example of a feature of the popular culture coming into conflict with the creationists' position concerns the 2014 version of the television series Cosmos (The Huffington Post, 2014). From the inception of the series, creationists have expressed their objections to the series content. Their most recent objection to the television series is that creation "science," including their young earth (i.e., usually less than 10,000 years in existence) position, has not been given equal time within the series. But the host of the show, Neal deGrasse Tyson, noted that science is not obligated to give equal time to ideas, particularly ideas put forth by people who oppose several widely accepted scientific conclusions.

Creationism in 2014

Although the creationists' agenda is not always consistent from organization to organization, their eagerness to promote their agenda is showing no signs of waning. For example, the 2013 "International Conference on Creationism" (ICC) was held last August in Pittsburgh, PA (Creation Science Fellowship, Inc., 2013). The conference was, however, only attended by 354 people, but was podcast to another 29 groups and individuals. Similarly, the Answers in Genesis organization is scheduled to hold their five day "Creation to the Cross" conference this June 21-25, 2014 in Costa Mesa, CA. The conference boasts sessions on such themes as: "Fossils: Buried in the Flood, Not Evolution Over Millions of Years," "Evolutionism: A Religion Masquerading as Science," "Evolution's assault on the Last Adam and the Gospel," "Dinosaurs and the Gospel," "Genesis Creation and Astronomy," "Genesis Compromise and the Decline of the Church," and other content consistent with their agenda (Creation to the Cross, 2014).

Although polls consistently demonstrate that a large percentage of Americans support some form of creationism (Hopkins, 2007), the level at which they hold those beliefs is not as clear. For instance, there has been a shortage of enthusiastic creationists willing to pay the entrance fee needed to peruse the $27 million Creationist Museum in Kentucky, which experienced a 10% decline in attendance in 2012 from the previous year. The museum has undergone a four-year slump in attendance and the parent organization, Answers in Genesis, reported a 5% drop in revenue last year as well. Thus, a belief in creationism at some level, does not necessarily translate to support for the *special creationist* agenda and the related programs (Stern, 2013).

In 2010, Ken Ham's Answers in Genesis organization announced plans to build a $150 million theme park in Kentucky, but after private donations failed to keep pace with the construction time frame, the project was postponed (Associated Press, 2014). But then early in 2014, a municipal bond offering raised enough funds to begin development of the estimated $73 million "Ark Encounter" project, which will house real and robotic animals for visitors to peruse. Thus, although the creationist movement has experienced some financial shortcomings (Stern, 2013), their cause seems not to have greatly slowed (Associated Press, 2014).

Not surprisingly, a 2006 Pew Research Center poll conducted in the United States indicated that evangelical Christians represent the strongest opposition to evolution (Pew Research, 2006). Most evangelical Christians hold to a literal translation of the Bible and reject evolution as contrary to *special creation*. The Pew poll indicated that 65% of evangelical Christians believe that life forms have not evolved. Just 28% of white evangelicals and 23% of black evangelicals believe evolution occurs. Only 10% of evangelicals believe evolution occurred through natural selection. The same Pew poll indicated that the majority of people within most other religious groups believe life forms have evolved. Statistics indicated that 59% of Catholics, 62% of white mainline Protestants, and 83% of secularists believe evolution has occurred.

Significantly, the majority of people are aware there is a virtual scientific consensus among scientists concerning evolution, but knowledge of a consensus among scientists has not influenced their attitude concerning evolution (Pew Research, 2006). The Pew Research poll indicated that 62% of people believe scientists are in agreement concerning evolution, but just 51% accept evolution themselves. True to form, evangelical Protestants are the exception in that 43% believe scientists are in agreement on evolution, but only 28% believe evolution of life forms takes place.

Effects of Creation Controversy on Students

Educators are charged with advancing the intellectual development of students, by way of imparting the established knowledge, as determined by a consensus of the experts within the various disciplines (Reference). It is the nature of empirical science, as this research has copiously demonstrated, that new facts are continually being discovered, and many theories are revised, abandoned, and even replaced. However, educators are obliged to teach the currently accepted facts related to each discipline, irrespective of: (1) whether or not particular groups or individuals agree or disagree with those facts; (2) whether or not a particular theory is subject to later revision or reversal at some future point in time; and (3) whether or not a particular theory is consistent with a theological or sociological point of view.

It is the case, for instance, that some groups of people believe the Apollo Moon landings never occurred, but were faked within a colossal and enormously successful fraudulent campaign carefully orchestrated by NASA (Fake Moon Landings, n.d.). There are other groups who contend the earth is flat – not a globe (Simanek, 2006). Nonetheless, science textbooks should not: (1) exclude references to the Moon landings; (2) be obligated to explicitly state the Moon landings are a "theory;" (3) or include an alternative explanation of the Moon landings because some groups believe the Moon landings never occurred. The same, of course, is true for the evolution of life forms, as well as the age of the earth and universe. In point of fact, the groups who: (a) refuse to concede the earth is a globe (Simanek, 2006); (b) discount evidence suggesting the evolution of life forms and profess *special creation* and "creation science" (Answers in

Genesis, 2012); (c) hold to a young earth, usually less than 10,000 years in existence (Answers in Genesis, 2012) (Marrapodi, 2012); and profess the Moon landings were a hoax (Fake Moon Landings, n.d.), are all biblical literalists.

Inevitably, students who were taught creationism in high school know considerably less about evolution when they enter college (Moore & Cotner, 2009). Also, students who were taught about evolution from their churches and media sources know considerably less about the theory of evolution than students whose primary source of knowledge about evolution was derived from their high school biology classes (Moore, Brooks, & Cotner, 2011). Also, students who embrace strict creationist views are not only opposed to the theory of evolution, but also oppose scientific claims related to the age of the earth and universe, which some educators believe to be more problematic in terms of their scientific literacy upon graduation (Davis & Kenyon, 1993; Larson, 2002; Cotner, Brooks, & Moore, 2010; Skehan & Nelson, 2000).

Research indicates that in general, students entering college know very little about evolutionary theory (Moore, et al., 2011). Research has shown that the principal factors that contribute to scientific illiteracy regarding evolution are: (1) personal religious beliefs that discount the evolution of life forms; (2) the absence of classroom instruction on evolution during high school; and (3) instruction in "creation science" during high school (p. 222). The above listed factors contributing to scientific literacy are not at all surprising when one considers that at least one-fourth of United States public high school students are taught "creation science" in their high school biology courses. Also, depending on the study, research has indicated that between 16 and 33% of United States public high school students are not taught evolutionary science in their high school biology classes (p. 224).

Although the focus is rightfully on student knowledge, the reality is that the ongoing popularity of “creation science” in United States public high school biology courses is directly linked to biology teachers’ religious beliefs (Moore, et al., 2011). How teachers view a subject directly influences how they teach a subject and many United States public high school biology teachers teach “creation science” because it is consistent with their personal religious beliefs. The extent of the problem is illustrated by the fact that almost one-fourth of United States public high school biology teachers believe “creation science” is scientifically valid. By contrast, 15% of the teachers in the same group do not believe evolution is scientifically valid. A related study concluded that 39% of public high school biology teachers in the State of South Dakoda believe that creationism should be taught in public schools. Creationism has long been popular among biology teachers and there is no evidence that improved state educational standards, proclamations by professional organizations, and decades of science education reform have made much difference (Moore & Cotner, 2013). Finally, one-sixth of United States public high school biology teachers believe in young-Earth creationism, which is “a worldview dictated by Biblical literalism that rejects modern biology, geology, chemistry, paleontology, and other sciences” (Moore, et al., 2011, p. 225). In conclusion, one should not be surprised to learn that the scientific literacy of a large percentage of incoming college students is marginal when one considers their high school teachers’ views concerning “creation science.”

A critical distinction should be considered at this point: knowledge of a subject is not the same as the acceptance of a subject (Moore, et al., 2011). Educators are legitimately charged with conveying the established knowledge, as determined by a consensus of the experts within the various disciplines. But another critical element of education is to foster critical thinking among students. Thus, although educators may prefer to influence student opinions, it is not as clear that changing a student's opinion regarding a subject – even evolution – should be the priority. In other words, teaching subject matter to students and encouraging them to think critically about a subject or issue, which often means discarding previously held opinions and prejudices, is the legitimate goal. Thus, educators should legitimately encourage students to consider all of the facts and draw their own conclusions. A teacher is then intimately concerned with their students' knowledge, but whether or not their students' opinions change is ultimately beyond the teacher's control.

Summary of Outcomes

The central research question herein necessitated this thorough exploration of the historical relationship of faith and science, as it pertains to the current twofold challenge confronting educators in 2014, in relation to science curriculum and pedagogy. The first aspect of the challenge concerns the creationist versus Darwinist conflict, in which creationists seek to prohibit the teaching of evolution and at the same time promote "creation science" in public schools. Creationists have challenged the teaching of evolution in United States courts, in state legislatures, and among local school boards in several states. In an effort to bolster their position, they have published "creation science" textbooks, in which they attempt to reinterpret scientific findings in light of their hyper-liberal reading of the Bible. Some local school boards have approved “creation science” textbooks for use in their public school science classrooms.

The second challenge confronting educators concerning science education is a series of centuries-old myths related to faith and science that are carelessly retaught to succeeding generations. The Galileo affair undoubtedly represents the most well-known and most often repeated of such myths related to the relationship of faith and science, but there are several others. Regrettably, these science myths are by now so ingrained in the public consciousness that they are generally considered "common knowledge." Unfortunately, in their attempt to discredit creationists, Darwinists routinely repeat these science myths, which only add to the turmoil and confusion.

Central Research Question Analysis

What additional facts and insights may be learned through a thorough exploration of the historical relationship of faith and science, in light of current challenges confronting educators?

This comprehensive survey, including the ancient history surrounding the various starts, stops, progress, regression, and eventual commencement of genuine science, was undertaken as a means to help clarify various elements of what is often a convoluted and confusing debate encircling science education in public schools. This research has revealed that a people’s faith tradition often provides the context through which they interpret and make sense of their world. Faith acts as a powerful lens through which a person views, interprets, and understands the world. More specifically, a person’s theological outlook either allows or disallows certain possibilities – even possibilities concerning nature.

There is no evidence to indicate any ancient civilization of record ever seriously considered or even imagined that the causes of natural phenomena could be discovered, apart from attributing supernatural influences as the cause (Jaki, 2000). Conversely, there is a great deal of evidence that indicates ancient civilizations believed the cosmos to be completely unpredictable and unintelligible, as it was controlled by a pantheon of gods (Jaki, 1990; Stark, 2003; Woods, 2005). Accordingly, the religious beliefs of all ancient civilizations in recorded history with the lone exception of Judaism (Aiken, 1911), were pagan (i.e., nature controlled by the unpredictable whim of the pantheon of gods) and/or pantheistic (i.e., the universe itself is divine and consequently subject to unpredictability). Moreover, most ancient cultures also held animistic beliefs (i.e., all physical entities, such as, plants, animals, and inanimate objects possess souls, a spiritual essence – even desires).

As direct result of their theological beliefs, the pagan, pantheistic, animistic worldview profoundly shaped how ancient people interpreted nature and natural phenomena. If a multitude of gods control the wind, rain, thunder, temperature, stars, moon, planets, etc., there is simply no reason to investigate the causes of natural phenomena. One already knows the gods are in control and nature is subject to the whim of the unpredictable gods. Thus, the presupposition of paganism and pantheism is that nature is unpredictable and unintelligible because the gods are unpredictable and their desires are a mystery. Whereas, the presupposition of empirical science is that nature is predictable and intelligible because it is governed by fixed laws of nature.

It is the case that even the most sophisticated ancient cultures never produced communities of scientists, systematic theories, or embarked on systematic empirical observations of nature (Jaki, 1990; Jaki, 2000; Woods, 2005; Walsh, 1915). The history of initial promise and inevitable collapse of efforts toward achieving science in every ancient civilization of record, demonstrates that pagan and pantheistic religious beliefs do not provide a fertile environment for an authentic investigation of nature and natural phenomena. This research has demonstrated that although the most advanced of ancient empires, including, Egypt, India, China, Greece, Aztec, Inca, and Mayan civilizations often demonstrated marked ingenuity and technical inventiveness in a variety of ways, none ever developed nor seriously ventured to develop empirical science (Jaki, 1990).

Ancient Greece made the most progress toward achieving genuine science, but like all other ancient civilizations of record, never succeeded in freeing themselves from pagan and pantheistic presuppositions in their quest to comprehend and explain natural phenomena. For example, in keeping with his philosophical approach, Socrates devoted his energies into wondering if it was *best* for the earth to be of a certain size or shape, rather than what exactly is the earth's size and shape. Aristotle compared animal digestion with earthquakes and the motion of the heavens and reasoned that rocks fall to the ground because of their love for the center of the world (Jaki, 1990). Such pantheistic and animistic speculations do not equate, in fact, fall well short of authentic scientific enquiry and theory.

Thus, the rise of science within a civilization is then, far from a normal feature of cultural progress inherent in the development of civilizations (Stark, 2003). The culture that finally conceived of, advanced, and disseminated empirical science throughout an entire civilization was infused with a radically different worldview than that offered by paganism, pantheism, and animism. This research has revealed that Christianity first provided the theological premises, presuppositions required for the eventual development of empirical science. The radically different belief that Christians were absolutely unwilling to compromise on from the beginning is that an Intelligent Creator (i.e., the *Logos*), created an intelligible universe, which a people endowed with intellect (i.e., in the image of God) are capable of comprehending. Thus, for the first time in recorded history, a people were resolute in their belief that the investigation of the natural world – apart from attributing supernatural explanations – is in keeping with the understanding that the cosmos is God's creation (Hess & Allen, 2008; Jaki, 2000; Stark, 2003; Woods, 2005).

The earliest Christians identified Jesus Christ as the *Logos*, Who created all that is visible and invisible (Lebreton, 1910). Identifying Christ as the *Logos* was a radical idea that fell in stark contrast to earlier attempts by pagan and Jewish thinkers to define the *Logos*, such as: an unidentifiable underlying principle that animates the universe; an intermediary agent of some sort between God and the universe; the totality of ideas; an impersonal power; the law that regulates the world; or a Platonic ideal model of the world. In opposition, the authors of the New Testament consistently asserted that Jesus Christ is the creative Word (*Logos*) of God:

> In the beginning was the Word (*Logos*), and the Word was with God, and the Word was God. He was in the beginning with God. All things came to be through Him, and without Him nothing came to be…And the Word became Flesh and made his dwelling among us, and we saw His glory, the glory as of the Father's only Son, full of grace and truth (John 1:1-3, 14).

From its inception, Christian theology made the radical and uncompromising claim that Jesus Christ is the rational, absolute, omnipotent, Creator and Lawgiver, Who, in keeping with His nature, instilled absolute rationality in all of creation (Gregory, 2012; Horn & Wiedenhofer; Royal, 2006; Woods, 2005). The New Testament itself gives an account of the various ways in which Christ revealed His divine nature by expressing His power over nature itself (i.e., walking on water, calming the sea, healing the deaf and blind, raising people from the dead, and resurrecting from the dead, etc.). The perception of a Divine Person as the very embodiment of the rationality and order of the universe (i.e., *Logos*) is a concept that was absent from all previous cosmologies, but one which ultimately provided a fertile environment for the development, sustenance, and advance of science (Hess & Allen, 2008; Jaki, 1990; Stark, 2003; Woods, 2005).

First Research Subquestion Analysis

What significance, if any, can be attributed to faith in the development of science, during the period between the fall of the Roman Empire through the Renaissance?

Christianity provided the theological foundation that first enabled a people to perceive that the cosmos itself is intelligible, logical, predictable, and comprehensible (Jaki, 2000; Stark, 2003; Woods, 2005). The realization of the theological underpinnings of science was a consummate first step in the history of science, but other essential elements soon converged, which together resulted in the eventual development and advance of the discipline of science. The convergence of ideas and essential elements that ultimately propelled the development of empirical science took place within Christian Europe in the historical period between the fall of the Roman Empire in 476 A.D. (Ancient, 2013) and the Renaissance (Hannam, 2011; Hess & Allen, 2008; Jaki, 1990; Stark, 2003; Woods, 2005). Beyond the theological underpinnings, three additional components were present from the beginning, which proved essential for the rise of empirical science: (1) institutional; (2) technological; and (3) theoretical (Hannam, 2011).

Institutional Advances Fostered Science

Both the monastery and later the university systems, which were dispersed throughout the European continent, were irreplaceable institutions in the development of science (Woods, 2005). Many of the ancient monasteries were already in place at the fall of the Roman Empire in 476 A.D., also known as the onset of the Dark Ages, and tens of thousands were flourishing within Europe by the onset of the Higher Middle Ages. Both monasteries and universities dedicated themselves to advancing scholarship and learning, and significantly, both were uniquely suited for the dissemination of knowledge, including new discoveries. The monasteries were, in effect, the scholarly and academic precursors to the universities that later emerged, as the monks had diligently protected, copied, studied, and often mastered the various aspects of classical learning. It is quite clear that the monks saved, protected, and preserved the bulk or possibly the entire

Greco-Roman classical learning tradition during the period known as the Dark Ages (Paparella, 2008; Woods, 2005).

The concept of a higher educational institution comprised of professional facilities, required courses of study, various specializations, examinations, undergraduate and graduate studies, and degrees, first arose in medieval Europe (Woods, 2005). More specifically, the very concept of a 'university,' so essential for the rise and development of science, was conceived of and developed by the Catholic Church beginning in the 12th century. The university system was virtually a natural extension or consequence of the value the Church placed on scholarship and learning (Grant, 2002; Woods, 2005; Pace, 1912). From the 12th century onward, every important discussion, hypothesis, theory, advancement, and achievement in any scientific discipline, originated within the realm of the monasteries or universities (Lindberg, 1992; Rait, 1918; Woods, 2005).

Both monastic and university scholarship were widespread throughout Europe and significantly, both enjoyed a common culture and language. By the close of the Dark Ages the various barbarian regions had been converted, so during the advance of empirical science the whole of Europe was Catholic and the Catholic culture permeated daily life. Correspondingly, the scholarly community shared in this common culture and also common language, so all scholarly writing was in Latin and all university courses were taught in Latin (Lindberg, 1992; Woods, 2005). The monastic and university institutions engendered by the Catholic Church, were the basis of the infrastructure that cultivated and disseminated learning and advanced the sciences throughout Europe (Woods, 2005).

Technological Advances Fostered Science

The monastic network of communication throughout Europe effectively disseminated scholarship and technological innovations, as monks regularly traveled between monasteries for the purpose of sharing information (Woods, 2005). Due to their unprecedented access to knowledge, monks became the leading experts in the various scholarly disciplines and practical arts, such as, agriculture, animal husbandry, brewing, winemaking, beekeeping, cheese making, fishery management, metallurgy, marble extracting, salt mining, glass work, and clock making (Paparella, 2008). The shared technical innovations greatly increased efficiency and improved the conditions of life in and around the monasteries (Hannam, 2011).

In addition to improving daily life, technical advances were often beneficial to natural philosophers (i.e., medieval scientists) in their work. Technical advances sometimes offered clues as to how things worked and other times were technologically useful to natural philosophers in their work (Hannam, 2011). Technology informing science during the Higher Middle Ages is the inverse of what typically happens in the 21st century. Modern science typically informs and propels technology forward, but in its beginning stages, science was frequently helped along by the development of new technologies. For example, glassmakers in Venice and Pisa worked to perfect their craft and by the 13th century a glassmaker had invented spectacles (Hess & Allen, 2008; Jaki, 1990). Venetian glassmakers were expert in grinding lenses, which enabled Galileo, who was working nearby, to significantly improve the performance of the telescope (Hannam, 2011).

Another example of technology preceding and assisting science concerns the study of magnetism. The ancient Chinese had long before recognized the existence of magnetism, but had only used it in geomancy (i.e., a form of divination) and *feng shui* (i.e., the belief that energy flow is governed by spatial arrangement) (Magnetic Lab, 2013), whereas, European natural philosophers were inspired to investigate the nature of magnetism itself. Another example of technology assisting science concerns the clock. Soon after the invention of the mechanical clock, with its 24-hour cycle, Thomas Bradwardine and Nicole Oresme began to use the metaphor of the universe as a clock created by the Divine Clockmaker (Hannam, 2011), which defined their cosmological theorizing and later aided Copernicus as he developed his Heliocentric model (Duhem, 1911).

In the early stages of scientific development, technological advances preceded, often informed, and sometimes aided those studying and advancing scientific enquiry (Hannam, 2011). Thus, although in the early stages of scientific study technology often preceded science, it was the scientists who ventured to grasp the nature of the natural phenomenon associated with the invention. Consider that although many ancient civilizations were very technologically advanced, such as ancient Egypt and China, they never engendered a community of scientists who strove to apprehend the nature of new discoveries. Because of their persistent efforts to understand the workings of nature, Christian Europe attained technological advances never imagined by other cultures.

The final essential element Christian Europe engendered that enabled the development and advance of empirical science was the development of theory that rejected any notion of supernatural causes or explanations.

Theoretical Advances Fostered Science

The commonly accepted features of empirical science are: (1) the development of theory; (2) controlled experimentation; and (3) careful observation of results (Lindberg, 1992; Stark, 2003; Woods, 2005). These specific features that literally differentiate empirical science from mere random discovery were not slowly recognized through time by now unidentified people. Far from originating in an unknown milieu, these specific attributes of authentic scientific investigation were established as the basis of scientific investigation by three historical figures of the 12th and 13th centuries: Robert Grosseteste, St. Albert the Great, and Roger Bacon (Lindberg, 1992; Walsh, 1915; Woods, 2005).

After the parameters of empirical science were established, a succession of theorists moved science forward. Some examples of theorists advancing science are: (1) the 14th century's, Thomas Bradwardine, who demonstrated that a successful mathematical description of nature should accurately describe natural phenomena (Hannam, 2011); (2) The brilliant mathematicians of Oxford University known as the Merton Calculators successfully merged mathematics and physics for the first time, which is an idea Aristotle had specifically rejected; (3) The Merton Calculator, John Buridan then developed his impetus theory, which was a vital step in establishing modern mechanics, as he applied his impetus theory to explain why a planet moving in a vacuum of space would keep moving until interrupted. Buridan's theory also explained why the planets are not moved by the gods or angels, but are moving in a vacuum, and why a person standing on the earth does not feel the rotation of the earth. (4) William Heytesbury soon developed the Mean Speed Theorem, which explains the motion of an object that is subject to constant acceleration (5) and Nicholas Oresme substantiated Heytesbury's theory by depicting it on a graph. (6) Following the achievements of his predecessors, Nicholas of Cusa theorized that the universe is far more immense than was thought by previous generations. Stark (2003) noted that a series of scholastics had already established the parameters of empirical science and advanced conclusions concerning the science of mechanics that were so well formulated that Copernicus simply accepted their validity and did not even attempt to improve upon them.

This comprehensive examination of the historical relationship of faith and science through time has revealed that at its inception and deep into its development, science and the Christian faith were intimately connected. The Christian faith provided the theological grounds that justified the systematic study of nature, which previous cosmologies had overlooked or flatly rejected (Jaki, 2000; Stark, 2003; Woods, 2005). The Catholic Church established the monastery and university systems throughout Europe, which served as the institutional infrastructure used to share information and collaborate with colleagues. Christian Europe experienced marked technological progress, which in the early stages of science, often aided scientists in their work. Christianity engendered science, so it was natural that the first authentic scientific theorists were Christian thinkers. For example, Robert Grosseteste, St. Albert the Great, Roger Bacon, Thomas Bradwardine, John Buridan, William Heytesbury, Nicholas of

Cusa, and Nicholas Copernicus were all Catholic clerics. Moreover, until the onset of the Protestant Reformation in 1517, virtually every significant scientific discovery was made by a Catholic bishop, priest, or monk (Woods, 2005). Science is still advanced within thousands of research universities worldwide, which more than reflects the original arrangement initiated by the Catholic Church more than 800 years ago.

It is the case then that the Christian faith was instrumental and seemingly irreplaceable in the initiation, development and progress of science, up to and even beyond the Renaissance era.

Second Research Subquestion Analysis

What importance does the historical origins and progress of science hold in informing the continuing creationist versus Darwinist conflict within education?

This comprehensive research concerning the historical origins and progress of science has revealed that authentic science first arose and developed within the context and confines of the Christian faith, and significantly, science failed to take root within the context of any other religion, spirituality, or nonreligious tradition (Hess & Allen, 2008; Jaki, 2000; Stark, 2003; Woods, 2005). Nonetheless, although Christianity provided the theological underpinnings essential for the emergence of science (Jaki, 2000; Stark, 2003) and Christian Europe encompassed the institutional, technological, and theoretical features necessary for the progress of science (Hannam, 2011; Woods, 2005), a historically recent phenomenon arose within 19th century Protestantism, which effectively disregards and attempts to undermine authentic empirical science (Skehan & Nelson, 2000).

In 1878, a group of Protestant ministers known as the Princeton Calvinists assembled for the First International Prophetic Conference, during which they proposed an innovation in biblical exegesis they termed “inerrancy” (Sandeen, 1967). “Inerrancy” had been used in biblical exegesis for centuries, but for the assembled Calvinist leaders, inerrancy took on an entirely new meaning. The Princeton Calvinists dramatically redefined inerrancy to mean every word of the Bible is true in every sense, which led a group of Protestants to begin interpreting the Bible in a hyper-literal sense (Skehan & Nelson, 2000).

Evangelical fundamentalist Christianity grew out of the Princeton Calvinist movement and the fundamentalist reading of scripture, such as the creation accounts in the Book of Genesis, led fundamentalists to conclude creation took place in six, literal, 24-hour days, which is the basis of creationism (Sandeen, 1967). Their hyper-literal biblical exegesis has elicited several conclusions that are entirely incompatible with the claims of modern science (Skehan & Nelson, 2000). Undoubtedly, the most well-known of the Creationists’ objections to modern science is their aggressive opposition to the theory of evolution (Larson, 2003; NCSE, 2012), but their denunciations of the claims of modern science are not confined to biological evolution.

Creationists also believe the Earth and entire universe came into existence less than 10,000 years ago (Horn & Wiedenhofer, 2008; Skehan & Nelson, 2000), human beings lived alongside the dinosaurs, and they interpret all geological evidence in light of Noah’s flood (Numbers, 2002). Flood geology was first proposed by the Seventh Day Adventist prophetess, Ellen G. White, and evangelical Christians soon joined the cause to promote the doctrine (Numbers, 2002). The result is that creationists do not only object to the teaching of evolution, but also reject a multitude of findings within several independent scientific disciplines, such as, anthropology, archeology, astrophysics, biology, earth science, geology, and physics (Russell, 2002; Skehan & Nelson, 2000).

The traditional stronghold of support for the creationist movement from its inception has been the southern United States (Numbers, 2002). The Creationist Museum is located in Kentucky (Hopkins, 2007); the first anti-evolution legislation, which prohibited including Darwinism in textbook, was approved in 1923 Oklahoma (Larson, 2003); and more recently, in 1987, the United States Supreme Court ruled in Edwards v. Aguillard (1987) that the Louisiana law requiring Creation science be taught alongside evolution in public schools was unconstitutional on the grounds that Creation science promotes a particular religious belief.

Creationism is showing no signs of waning, as polls consistently indicate that a large percentage of Americans support some form of creationism (Hopkins, 2007). Predictably, according to a 2006 Pew Research Center poll, in keeping with their hyper-literal reading of the Bible, evangelical Christians represent the strongest opposition to evolution (Pew Research, 2006). Marrapodi (2012) concluded that notwithstanding their legal defeats, creationists are winning the cultural struggle involving evolution. Creationists possess the financial backing, numbers, and energy to continue their cause. The problem may be even deeper than a belief in creationism, however, as the 2006 Pew poll also indicated that the majority of Americans are fully aware of the scientific consensus regarding evolution, but still disregard it. In other words, many United States adults are suspicious of science in general, which helps the creationist cause.

Evolution and Creationism in Public Schools

Public school educators and their students remain in the midst of the conflict concerning science instruction and curriculum content (Skehan & Nelson, 2000). Many students perceive that the creationist versus Darwinist dispute all too often sets personal religious beliefs, family values, and the educational culture in opposition (Pecora, 2007; Scheitle, 2011; Zimmerman, 2002). Moreover, research indicates that in general, students entering college possess little knowledge about evolution (Moore, et al., 2011). The primary factors that contribute to scientific illiteracy regarding evolution are: (1) personal religious beliefs that discount the evolution of life forms; (2) the absence of classroom instruction on evolution during high school; and (3) instruction in "creation science" during high school (p. 222). Studies indicate that between 16 and 33% of United States public high school students are not taught evolutionary science in their high school biology classes (p. 224). The predictable result is that students who were taught creationism in high school science classes know considerably less about evolution when they enter college (Moore & Cotner, 2009).

Although the focus is most often on students, the reality is that the popularity of "creation science" in United States public high school biology courses is directly linked to biology teachers' personal religious beliefs (Moore, et al., 2011). For example, almost one-fourth of United States public high school biology teachers believe "creation science" is authentic and accurate. These research results indicate that creationists are making significant progress in promoting their doctrines within United States public schools and the American culture as a whole (Marrapodi, 2012).

Analysis of the Conflict Thesis

The ongoing creationist versus Darwinist debate is very often characterized as a conflict between science and religion or faith and science (Dawkins, 2006; Harris, 2004; Knight & Lomas, 2001; Stark, 2003; Wiker, 2011). The "conflict thesis" or "conflict theory" charges that faith and science are mutually exclusive, contradictory concepts, and thus, remain in unremitting conflict (Wilson, 2002). For conflict theorists, the creationist versus Darwinist conflict is simply the most recent example of religion's universal opposition to science. Conflict theorists forcefully assert that religion has continually and deliberately hindered the development of science through the centuries (Dawkins, 2006; Draper, 1874; Harris, 2004; White, 1896).

Royal (2006) noted that the conflict theorists have successfully advanced their own cause within the culture. One powerful strand in the conflict theory "maintains that the Greeks represent reason and enlightenment…and that Christianity, especially in its Roman Catholic version, is irrational and superstitious" and that "the early Christians suppressed Greek thought and science when they got the upper hand in Rome, leading to the closing of the Western mind" (p. 142). As a result, the majority of modern Americans and Europeans believe Christianity's legacy in the West "is a history of Dark Ages, Crusades, Inquisitions, opposition to science (e.g., Galileo), religious wars, and various other forms of intolerance" (p. 142). For conflict theorists, then, the fundamentalist

Christian opposition to Darwinism is simply the latest evidence proving their thesis (Dawkins, 2006; Harris, 2004).

Myths of the Conflict Thesis

A fierce, public debate over the relationship of faith and science began following the Protestant Reformation, took hold in Europe during the Age of Enlightenment (Ecklund & Park, 2009; Stark, 2003), gained renewed momentum in the late 19th century (Draper, 1874; White, 1896), and continues in 2014 within both academia and in the popular media (Dawkins, 2006; Harris, 2004; Schaefer, 2011). During the 18th century's Age of Enlightenment, a group of European intellectuals began to advance what would become the central tenet of the Enlightenment era: The only reliable truths are those truths which are derived through empirical means, which ironically is itself a proposition that cannot be proven or derived through empirical means (Pernoud, 1977/2000; Woods, 2005).

Beginning in the Age of Enlightenment and throughout the intervening centuries, a series of myths surrounding faith and science began to circulate, which have been repeated so often they are now generally considered "common knowledge" (Pernoud, 1977/2000; Woods, 2005). The myths, regularly reprinted in modern textbooks, are all rooted in the idea that faith and science are opposed (Numbers, 2009; Pernoud, 1977/2000; Singham, 2007; Stark 2003; Woods, 2005). As it was the objective of the Enlightenment thinkers like Voltaire to do away with the Roman Catholic Church and because the myths served Protestants well in their efforts to evangelize their people, the myths concerning religion's relationship to science almost all, if not all, concern the

Catholic Church. For example, all of the following assertions concerning the Catholic Church and science are fallacious, but all appear in various forms within school textbooks:

- science was strenuously hindered by the medieval Catholic Church because the Catholic Church opposed science (Pernoud, 1977/2000; Stark, 2003; Wiker, 2011; Woods, 2005)
- the Catholic Church was opposed to human dissection (Hannam, 2011; Stark, 2003)
- Columbus and his crew feared they would fall off the edge of the flat Earth on their journey across the ocean (Singham, 2007)
- medieval people never knew the time of day because they had not invented clocks yet, hence they were living in the Dark Ages (Pernoud, 1977/2000)
- during the Middle Ages the Catholic Church vigorously obstructed academic freedom (Hannam, 2011; Lindberg, 1992; Stark, 2003; Woods, 2005)
- a pope in the Middle Ages issued an edict that forbade the practice of chemistry (White, 1896)
- Pope Callistus III was given the title "the silly pope," as he was falsely said to have believed Halley’s comet was on a collision course with Earth, so recited fervent prayers and ordered that all of the church bells in the city be rung in order to change its path (Draper, 1874; Walsh, 1915)

- Copernicus was an isolated monk, who somehow conceived of the idea that the Earth revolves around the Sun, as he was far removed from the intellectual centers of Europe (Cubberley, 1920; White, 1896)
- Galileo was tried, tortured, imprisoned in a dungeon, and/or condemned to death because he said the Earth revolves around the Sun (Pernoud, 1977/2000; Stark, 2003; Wiker, 2011; Woods, 2005)
- Heliocentrism was saved from the clutches of the Catholic Church by the enlightened Protestants, who rescued the theory (Stark, 2003; Woods, 2005)
- during the 1,000 year period of the so-called "Dark Ages" of human history, little or no scientific progress occurred, and in fact, the entire period between the fall of the Roman Empire to the beginning of the Renaissance was an interruption to mankind's progress (Hannam, 2011; Pernoud, 1977/2000; Stark, 2003; Woods, 2005)
- science was unable to advance and prosper until the Protestant Reformation of the 16th century successfully stripped the Catholic Church of its power and influence (Knight & Lomas, 2001; Woods, 2005)

The above is a significant list of false assertions that have been reiterated time and again for more than two centuries. Leading scientists, like Stephen Hawking, repeat the myths and take their validity for granted (Wiker, 2011) and Darwinists frequently resort to using many of these myths in their fight against creationists (Dawkins, 1996). Unfortunately, these myths have made their way into the public consciousness primarily by means of school classrooms, and significantly, add to the confusion surrounding the perceived conflict between faith and science (Pernoud, 1977/2000).

Actual or Fictitious Conflict

This research has cogently demonstrated that there is no intrinsic conflict between faith and science. This historical survey has, however, revealed the undeniable fact that many faith traditions are inherently opposed to, and thus, conflict with science (Jaki, 1990; Jaki, 2000). Pagan, pantheistic, and animistic faith traditions all engender a worldview, which presumes the universe is unpredictable. Either a multitude of gods control nature or the various elements of nature themselves (i.e., rocks, trees, the universe as a whole) possess divinity and desires. These pagan, pantheistic, and animistic beliefs are simply inconsistent with the essential presupposition of empirical science, which takes for granted that nature itself is rational and predictable. Also, although pagan, pantheistic, and animistic beliefs and faith traditions permeated ancient cultures, they are not a thing of the past. Eastern religions, such as, Hinduism, Hare Krishna, and Buddhism have millions of followers worldwide and the modern New Age movement is an admixture of various Eastern religious beliefs.

A present-day example of the application of pantheistic and animistic religious beliefs arose when a famous movie actress described why she believes water has feelings (Eby, 2014). Her explanation relies on pantheistic and animistic beliefs about nature, which led her to believe a human being’s energy and consciousness have effects on matter.

This dissertation has also revealed another form of religious belief that is wholly incompatible with the rational study of nature. Current fundamentalist religious beliefs practiced by both evangelical fundamentalist Christians and the majority of the Islamic faith embrace religious beliefs that are incompatible with the precepts of empirical science. In practice, fundamentalist religious beliefs, as observed within Christianity and Islam, act as a filter that allows or disallows facts, solely based on whether or not those facts seem to confirm or negate an aspect of their belief system – irrespective of the empirical evidence. By its nature, however, science is limited to explaining the natural world by means of natural processes. Consequently, supernatural causes or explanations simply fall outside of the bounds of science (Skehan & Nelson, 2000).

The preceding sections sufficiently documented the fundamentalist Christian opposition to science, wherein they reject any and all scientific conclusions that contradict their unique religious beliefs (Horn & Wiedenhofer, 2008; Skehan & Nelson, 2000). Islam, however, represents another contemporary example, in which a people reject science and the scientific process, as a direct consequence of their fundamentalist religious beliefs (Reilly, 2010).

Islam conquered what had previously been Christian nations and territories; as a result, Islam inherited a great appreciation of science from Christianity (Reilly, 2010). The early Islamic thinkers also accepted the Christian understanding that an Intelligent Creator created an intelligible universe, which a rational people are capable of understanding (Jaki, 1990). As a result, early in their history, Islam made significant contributions to science. Then three years after coming into existence, a fiercely contested philosophical and theological debate among Islamic scholars concerning the importance of reason, ultimately determined the fate of science within the Islamic world (Ferngren, 2002; Jaki, 1990; Reilly, 2010). One side came down on the side of reason, but their adversaries adamantly denounced the existence of scientific laws, as blasphemous and irrational. They concluded that the existence of laws of nature would deprive Allah of His sovereign freedom to act, and thus, would be an affront to Allah's supreme will (Stark, 2003).

Science in the Islamic world came to an abrupt end a millennium ago, when a group of fundamentalist Muslims triumphed over their religious brethren (Jaki, 1990; Reilly, 2010). Islam's rejection of the existence of laws of nature continues to have deleterious consequences within Islamic nations in the 21st century. Overbye (2001) noted how Hoodbhoy recalled that even in the 21st century, a Pakistani iman told physicists in Pakistan that they could not consider the principle of cause-and-effect in their work: "It was not Islamic to say that combining hydrogen and oxygen makes water. 'You were supposed to say that when you bring hydrogen and oxygen together then by the will of Allah water is created'" (Overbye, 2001, p. 3).

This research has shown that most religious traditions of record have significantly conflicted with the very notion of a free and unrestricted empirical investigation of nature. The ancient Christian faith, apart from the historically recent fundamentalist reinterpretation of Christianity, stands alone as the only tradition, religious or nonreligious, to provide the rationale and justification for the systematic study of nature. The parameters of empirical science were developed close to a millennium ago and have been applied throughout the Western world, particularly in the universities, since the 11th century. As a result, at this point in history, billions of people recognize that people are capable of perceiving many aspects of nature by means of empirical investigation, but that fact is not at all self-evident, as it has escaped the vast majority of human beings who have ever lived.

Darwin and Darwinism

Historically, it has been the case from the beginning that although it is acceptable to be critical of various scientific theories or aspects of a theory, such as, Einstein's Theory of General Relativity or the Big Bang theory, to criticize any aspect of Darwinism is viewed by the scientific community as tantamount to scientific apostasy (Stark, 2003). Even contemporary Darwinists have been judged to be evolutionary heretics after publically admitting any discrepancies they perceive within Darwin's theory (Dennett, 1996; Gould, 1980). Darwin and his earliest disciples diligently defended any attack or perceived attack against Darwin's theory, but from the beginning, his followers were particularly intent on discrediting any religious opposition (Stark, 2003; Wiker, 2009).

Darwin's principal disciple, Thomas Henry Huxley, bluntly expressed his characteristic, but not so scientific hope that he would witness: "Extinguished theologians lie about the cradle of every science as the strangled snakes beside that of Hercules" (as cited in Royal, 2006, p. 231). This unwillingness to accept any criticism of Darwinism remains a common trait among present-day Darwinists: "It is absolutely safe to say that, if you meet somebody who claims not to believe in evolution, that person is ignorant, stupid, or insane" (as cited in Stark, 2003, p. 177). The primary reason for the Darwinists current intolerance lies in the fact that they have been immersed in a century and a half long struggle with creationist. It follows then that upon any perceived criticism of Darwin's theory, Darwinists tend to accuse the critic of being either anti-evolution or a biblical creationist (Stark, 2003; Turner, 1984).

Darwinists' feelings aside, in this effort to shed light on the current creationist versus Darwinist debate that continues to disrupt science education in 2014, this dissertation required a candid and honest assessment of Charles Darwin's particular theory of evolution. In keeping with that end, it is noted that notwithstanding the fact that most Darwinists claim that Darwin solved the problem of how life came into existence on earth and afterward evolved into millions of different life forms (Dawkins, 1996; New York Times, 2005), their claims have failed to convince many members of the scholarly community, including some Neo-Darwinists (Raup, 1984; Stark, 2003; Wiker, 2011). The debate among scholars does not concern whether or not life forms have and continue to evolve. The fact that life forms evolve is an indisputable fact (Ayala, 2010; Muckermann, 1909; Horn & Wiedenhofer, 2008; Skehan & Nelson, 2000). The scholarly discussion specifically concerns whether or not Darwin's proposed evolutionary mechanism is, in fact, the mechanism by which the evolution of life occurs (Depew, 2013; Depew & Weber, 2011). Adding to the confusion, evangelical creationists mistakenly interpret the debate over the specifics of Darwin's proposed evolutionary mechanism as evidence against evolution itself and their misconceptions are reiterated within science classrooms across the United States (Moore & Cotner, 2013).

Darwin's theory of evolution is comprised of three principal elements: (1) natural selection; (2) common descent; and (3) random mutation (Behe, 2007). Darwin's assertion that all living organisms are derived from a common ancestor has been proven through DNA evidence. The tree of life, wherein all living organisms share common ancestry has been overwhelmingly confirmed by microbiologists (Ayala, 2010; Behe, 2007; Horn & Wiedenhofer, 2008). Darwin, however, understood that common descent itself does not account for the incredible variety of living species found on Earth, but hypothesized that random mutation paired with natural selection accounts for the diversity of species (Behe, 2007).

The most significant and common objection to Darwin's evolutionary mechanism concerns the criteria by which to judge his theory, which he offered in his *Origin of Species*: "If it could be demonstrated that any complex organ existed, which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down" and then added, "but I can find out no such case" (Darwin, 1964, p. 189). Darwin also rejected any notion that species could come into existence suddenly (Stark, 2003). "To admit such a possibility, is, as it seems to me, to enter into the realm of miracle, and to leave those of Science" (Darwin, 1993, p. 316). The exceedingly slow development of species over the course of geological epochs, as proposed by Darwin, is referred to as gradualism (Ayala, 2007; Ayala, 2010; Stark, 2003).

The fossil record did not suggest – much less prove – gradualism in nature, in Darwin's day and now, a century and a half later, the fossil record still does not support gradualism (Gould, 1972; Gould, 1977; Stark, 2003). Thirty-four years after the publication of his *Origin of Species*, Darwin expressed his frustration with the fossil evidence: “Why, if species have descended from other species by fine gradations, do we not everywhere see innumerable transitional forms? Why is not all nature in confusion instead of the species being, as we see them, well defined” (Darwin, 1993, p. 212)? On another occasion Darwin admitted: “the best preserved geological section presented, had the difficulty of our not discovering innumerable transitional links between the species which appeared at the commencement and close of each formation, pressed so hardly on my theory” (London Quarterly Review, 1923/2012, p. 128).

The specific geologic era Darwin and his successors have been unable to reconcile with his theory is the Cambrian period (University of California Museum of Paleontology, 2011). The Cambrian period commenced about 540 million years ago and lasted for about 40 million years. All life forms that existed on Earth before the Cambrian era were soft-bodied, which lacked any hard parts or structures (Choi, 2012). Paleontology has confirmed that the Cambrian period is the point in the history of life when the majority of the Earth’s modern animal groups first appeared (University of California Museum of Paleontology, 2011), but contrary to Darwin’s theory of gradualism, the animals seem to have emerged suddenly, already fully formed (Gould, 1972; Gould, 1977; Stark, 2003). Current research has narrowed the time frame to the first 13 million years of the Cambrian era, wherein the new species first appeared (University of California Museum of Paleontology, 2011) and this sudden emergence of fully formed species has generally been described as the “Cambrian Explosion” (para. 1).

The steadfast Darwinist, Richard Dawkins, (1996), expressed his confusion regarding the Cambrian evidence: “And we find many of them [modern animals] already in an advanced state of evolution, the very first time they appear. It is as though they were just planted there, without any evolutionary history” (p. 229). Increased field research has only underscored the incongruity, as a former curator of the American Museum of Natural History conveyed: "Many of the discontinuities [in the fossil record] tend to be more and more emphasized with increasing collecting" (as cited in Stark, 2003, p. 180).

Confronted with the fossil record, many Darwinists continue to search for the biological mechanism that can explain the sudden emergence of new species (Gould, 1980; Stark, 2003; Wiker, 2009). Other committed Darwinists occasionally express their astonishment with the fossil evidence, but then simply return to natural selection as the only acceptable evolutionary mechanism (Stark, 2003). Notwithstanding his admitted astonishment with the Cambrian fossil evidence, Richard Dawkins expressed the characteristic faith shown by Darwinists from the beginning: “I believe, but I cannot prove, that all life, all intelligence, all creativity and all ‘design’ anywhere in the universe, is the direct or indirect product of Darwinian natural selection” (New York Times, 2005, para. 7).

Although scientists have put forth alternative evolutionary theories that suggest alternative evolutionary mechanisms, they have generally been disregarded by the scientific community (Depew, 2013). Recently, however, researchers discovered evolution occurring in nature that is indisputably outside of the Darwinian model (Rohner et al., 2013). Researchers studying blind cavefish in Mexican caves discovered how variations inherited from earlier generations without triggering any physical changes in the animal, can be "unmasked" by the trauma of suddenly entering a new environment (Kenney, 2013, para. 3). This was the first time researches observed this evolutionary phenomenon in nature and they noted that the animal's ability to adapt was not only selected for, but also passed on to offspring. Again, this evolutionary discovery is significant because it falls outside the bounds of Darwin's threefold theory encompassing, natural selection, common descent, and random mutation (Behe, 2007) (Rohner et al., 2013).

Historical Basis of Opposition to Darwinism

By far, the most disturbing aspects of Charles Darwin's theory concern the misogynistic, racist, and inhumane aspects of his theory, which he himself brought to light in his exhaustive effort to explain his theory in "scientific" terms (Darwin, 1874). Again, his repulsive statements regarding women and a variety of groups and races of people were not written in a private diary or journal. The worst of Darwin's comments were published in his books that were written with the express intent to explain his theory in "scientific" terms (Darwin, 1871). Thus, his comments are not mere introspective, emotional meanderings about people, but are integral to his theory, as they are what he understood to be the natural consequences of his theory. Darwin's principal explanation and defense of his theory appeared in several editions of his, *The descent of man, and selection related to sex* and in his *The variation of animals and plants under domestication* (1868). Both books were published as further explanations of his theory and both included follow up "scientific research" of his theory, performed by various members of the scientific community of his day.

Darwin reiterated his 19th century prejudices in nauseating detail throughout his works, but always presented as "evidence" validating his evolutionary theory. A few examples will suffice to show the extent of Darwin's desperation to prove his theory. His understanding was that women are simply less evolved than men: "The chief distinction in the intellectual powers of the two sexes is shewn by man's attaining to a higher eminence, in whatever he takes up, than can woman" (Darwin, 1874, p.564). His colleague, Vogt (1864) set out to substantiate Darwin's theory and noted: "We need only place the skulls of the Negro, chimpanzee and idiot side by side, to show that the idiot holds in every respect an intermediate place between them" (Vogt, 1864, pp. 197-198). Darwin praised Vogt's research in the first edition of his *The Descent of Man* (1871) and went on to cite his work multiple times (Gelb, 2008). In his *The Descent of Man,* Darwin (1874) included a chapter entitled, "Resemblances between idiots and animals" (p. 35), in explanation of his hypothesis that mentally impaired people are representative of a sub-human class that clearly shows the condition of humans in an earlier state of evolution (Gelb, 2008).

As was all too customary in 19th century English society, Darwin (1874) didn't resist including a bigoted quote by one of his science colleagues regarding "The careless, squalid, unaspiring Irishman [who] multiplies like rabbits" (p. 138). The quote disparaging the Irish people was intended to lend support to his notion of the survival of the fittest, as it compared Irish Catholics to the Scottish Protestants, who were "frugal, foreseeing, self-respecting, ambitious,…stern in his morality, spiritual in his faith, sagacious and disciplined in his intelligence" (p. 138). But for Darwin and his colleague, the problem was that the Irish birth rate was greater than the Scottish birth rate, which seemed to indicate that in spite of the fact that the Scott's were a superior race of people, they would eventually be overcome by the "squalid, unaspiring Irishman [who] multiplies like rabbits" (p. 138).

It is undeniably that Darwin's theory of evolution inspired the eugenics movement, as expressed by another scientific colleague of Darwin's: "There is nothing either in the history of domestic animals or in that of evolution to make us doubt that a race of sane men may be formed," more to the point, sane men "who shall be as much superior mentally and morally to the modern European, as the modern European is to the lowest of the Negro races" (Galton, 1892, para. 7). In his *Descent of Man*, Darwin (1874) expressed great admiration for Galton's "scientific" eugenics thesis: "we now know, through the admirable labours of Mr. Galton, that genius…tends to be inherited" (p. 28). Darwin articulated his own eugenics thesis: "It is surprising how soon a want of care, or care wrongly directed, leads to the degeneration of a domestic race," but only "man himself" is subject to this evil because "hardly any one is so ignorant as to allow his worst animals to breed" (p. 134).

Specious Science

Upon scrutiny, Darwin's scientific methodology is found to be extremely deficient. For example, along with the denigration of entire classes of people in his effort to explain his theory in what is very often all too precise detail, he confidently stated that scientists had observed that the hands and jaws "are generally smaller in refined and civilised men than in hard-working men or savages, is certain" (Darwin, 1871, pp. 117-118). Darwin then carefully noted that research had revealed "that the hands of English labourers are at birth larger than those of the gentry" and did not neglect to mention that "the correlation which exists, at least in some cases, between the development of the extremities and of the jaws," confirms that "it is possible that in those classes which do not labour much with their hands and feet, the jaws would be reduced in size from this cause" (p. 117). Darwin noted that in his day, larger jaws and hands had been documented among laborers in England, than among members of the gentle class.

In his 1869 work, *The Variation of Animals and Plants under Domestication*, Darwin wrote that he was "forced" by the facts of biology to describe the specific means by which hereditary characteristics are past down generationally, giving rise to new species (Darwin, 1868, p. 357). He called his theory "pangenesis," but his pangenesis theory was soon debunked by his own cousin, Sir Francis Galton, who attempted to confirm the theory through the breeding of rabbits (Gillham, 2001). Darwin was originally very excited about his cousin's experiment and remained so in correspondence during the course of the research, until it proved his theory wrong. He then cut off communication with his cousin (Bergman, 2011).

Nineteenth-century, English, Caucasian elites regarded women and people of color as the white man's physical, intellectual, creative, and emotional inferior (Darwin, 1882). A product of the environment in which he lived, Charles Darwin's all too thorough explanations of his evolutionary theory provided a "scientific" justification for

19th century bigotry. In their desperate efforts to produce credible missing links, Darwin and his colleagues declared that mentally impaired people are something less than human and represent an evolutionary link between apes and modern humans (Gelb, 2008). It seems more than obvious that Darwin and his colleagues' personal prejudices profoundly shaped their "scientific" conclusions about evolution.

Sadly, Western society has not completely overcome or reversed the deep seated misconceptions regarding women, people of color, and the mentally disabled, which were repeatedly articulated by Charles Darwin and his friends in the scientific community – all under the guise of science (Junco, Merson, & Salter, 2010).

There is no doubt students should be taught evolutionary science in public schools because the evolution of life forms through time is a scientific fact (Ayala, 2010). Darwin's theory should, of course, be presented to students, but not the 21st century, sterilized version of Darwinism. Rather, there are many lessons to be learned from Darwin's own, gritty, 19th century version of his theory.

It must be noted that the fact that Darwin and his closest collaborators expressed various forms of bigotry in their "scientific" explanations of Darwin's theory, does not in and of itself, prove that Darwin's theory is wrong. The fact that his explanation of how characteristics are passed on to progeny through "pangenesis" was invalid also does not prove his evolutionary theory is wrong. However, the failure to produce credible missing links and the apparent complete absence of gradualism in the evolution of life forms should be openly discussed in science classrooms, along with the extremely negative implications of Darwinism for various races and groups of people, in light of Darwin's theory. The modern-day Darwinist, Richard Dawkins, was forthright about the natural consequence of Darwin's theory, "What's to prevent us from saying Hitler wasn't right? I mean, that is a genuinely difficult question" (para. 25). In light of Darwin's theory, it is difficult to say whether or not it was wrong for the Nazi's who held power, to exterminate the Jewish people, who were less powerful at the time. Regarding Darwin's theory of evolution, there is much that is not discussed in public school classrooms in 2014.

Twenty-first-century Intersection of Faith and Science

The intersection of faith and science has shown no signs of abating in the 21st century. In point of fact, several recent scientific discoveries in a variety of disciplines have magnified several convergences. For example, recent discoveries in physics and astronomy have caused a paradigm shift within the scientific community, wherein cosmologists have overturned the ancient and universally accepted notion of an infinite universe (Spitzer, 2010). The consensus among scientists now is that the universe came into existence at a singular point in history approximately 13.7 billion years ago, in the course of what has been termed the Big Bang event (Hawking, 1998; Lemaitre Bio, 2008, Overbye, 2014; Vilenkin, 2007).

The significance of the Big Bang theory for faith and science is in the fact that many of the world's most important cosmologists have acknowledged that an absolute beginning to the universe points to a Creator (Flew & Varghese, 2007; Spitzer, 2010). In a similar way, cosmologists have mathematically demonstrated the astronomical odds against this universe forming life supporting conditions (i.e., anthropic conditions) of any kind, particularly in light of the overwhelming odds in favor of this universe unfolding with conditions completely unhospitable to life. That is, the probability that the universe would contain non-anthropic conditions (i.e., non-life enabling conditions) is extremely more likely than possessing anthropic, life enabling conditions (Flew & Varghese, 2007; Spitzer, 2010; Vilenkin, 2007).

It must be said that although many people believe recent scientific conclusions point to the presents of a Super Intelligent Creator (Spitzer, 2010), empirical science is utterly incapable of proving that proposition, just as science is incapable of proving the reverse. Until the Age of the Enlightenment, virtually every natural philosopher (i.e., scientist) discussed herein, noted that their motivation for their work was grounded in their desire to better understand God's creation. For example, Newton the following concerning his motivation for discovery in his *Principia Mathematica* of 1713:

> Blind metaphysical necessity, which is certainly the same always and everywhere, could produce no variety of things. All that diversity of organisms which we find suited to different times and places could arise from nothing but the ideas and will of a Being necessarily existing….And that is enough concerning God, to discourse of whom from the appearances of things does certainly belong to natural philosophy (as cited in Hannam, 2011, p. 349).

Newton's sentiments still motivate many 21st century scientists (Horn & Wiedenhofer, 2008; Spitzer, 2010).

This dissertation has demonstrated that the conflict thesis, which posits that faith and science are at odds, contains a half-truth. Many faith traditions are wholly incompatible with science, insofar as they profess that the universe is unpredictable and thus, not subject to repeatable and predictable laws of nature (Jaki, 2000; Reilly, 2010). All pre-Christian civilizations of record, as well as the post-Christian, Islamic civilization, exemplify the fate of cultures that fail to conceive of the universe as rational. Whereas, the ancient Christian faith stands out in history as the only exception, as Christianity presupposes a rational and predictable universe (Gregory, 2012; Royal, 2006). As a result, science came into existence, advanced and prospered in Christian Europe (Crocker, 2001; Hannam, 2011; Hess & Allen, 2008; Jaki, 1990; Stark, 2003; Woods, 2005).

Modern-day Darwinists are correct in their judgment that the reality of the evolution of life is contrary to fundamentalist Christian and Islamic beliefs (Patheos, 2012; Reilly, 2010). But Darwinists are incorrect in suggesting that the evolution of life somehow discredits the Christian faith all together, to the extent that the ancient Christian faith has never been burdened by the hyper-literal reading of the scripture that has so predisposed fundamentalist Christians and Muslims against the claims of modern science. (Aquinas, 1261/1975; Augustine, 415/1982; Hess & Allen, 2008). For the overwhelming majority of Christians worldwide, evolution is not seen as an obstacle to the faith, but rather, as an expression of and in keeping with God's omnipotent power to develop nature through secondary causes (Aquinas, 1261/1975).

Notwithstanding the ancient Christian perception of creation, it is the case that science curriculum and pedagogy in United States public schools have been plagued by the creationist versus Darwinist conflict for a century and a half (David & Kenyon, 1993;

Larson, 2003), and also, contaminated with science myths, since at least the Age of Enlightenment of the 18th century (Pernoud, 1977/2000; Singham, 2007). Science curricula and pedagogy could be significantly improved by: (1) eradicating the long-standing science myths from school curricula; (2) a candid discussion of the significant ramifications of interpreting a historical document – any historical document – in a hyper-literal sense, versus an interpretive method that takes the various literary devices utilized in the time period into account, such as, the use of allegorical, figurative, poetic, symbolic, or apocalyptic imagery; (3) a comprehensive study of the theory of evolution, including evidence in favor of Darwinism (i.e., DNA evidence confirming common descent) (Behe, 2007); (4) apparent disconfirming evidence of Darwinism (i.e., the apparent absence of gradualism in nature) (Gould, 1980; London Quarterly Review, 1923/2012; Stark, 2003; University of California Museum of Paleontology, 2011); (5) alternative, credible evolutionary theories (Kenney, 2013); and (6) an honest discussion of Darwin's own statements concerning the evolutionary status of women, various people of color, the mentally impaired, the Irish people, and the "hard-working men or savages" in comparison to the "gentry" class of 19th century England (Darwin, 1871, pp. 117-118).

This dissertation concerning the historical relationship of faith and science has revealed a unique connection between faith and science. For most of human history, religions that permeated entire civilizations effectively stifle the very notion that people could grasp the workings of nature. Although most cultures now accept the complete rationality of the universe, that idea first arose only 2,000 years ago within the Christian world. It is the case then that Christianity gave rise to science and science developed within Christian Europe, but that fact alone has not prevented a group of present-day evangelical Christians from applying an innovative biblical exegesis that is incompatible with authentic empirical science. A religious system that opposes the conclusions of a variety of independent scientific disciplines should not be the arbiter of science curricula in public schools.

Chapter 5: Discussion, Conclusions, and Recommendations

Overview of Research Purpose and Objectives

Millions of United States and European public school students are in the midst of a long-enduring battle that is not of their own making. Both sides in the struggle claim they hold the truth and staunchly believe it to be a moral imperative that science curricula reflect their position. The primary dispute turns on how the universe came to exist and how it functions. Predictably, this battle over science curricula is also disturbing thousands of educators, who have taken on the responsibility to teach science to the next generation, but who must ultimately rely on their leaders and communities for guidance. The conflict over science curricula has raged in various settings for more than a century and has often been marked by contentious and vile assertions. This dissertation comprises my effort to sort through the complexity and misinformation characteristic of this continuing conflict, through the lens of a historian and educator.

The antagonists in the long-standing conflict over science education are proponents of creationism and their Darwinist opponents. Creationism, sometimes referred to as *special creation*, is the belief that the creation account in the Book of Genesis should be interpreted literally, as representing a literal 6-day creation, wherein God brought all matter and life forms into existence in essentially their present form, less than 10,000 years ago (Horn & Wiedenhofer, 2008; Skehan & Nelson, 2000). Darwinists have proposed a specific evolutionary theory that maintains the evolution of species occurs through three interrelated, but distinct processes (i.e., random mutation, natural selection, and common descent). Historically, the majority of Darwinists have held to an atheistic point of view, wherein the universe is thought to be infinite or have come into existence through strictly natural processes, thus eliminating the need for God (Royal, 2006; Wiker, 2011). Creationists and Darwinists affirm positions that are widely divergent and regrettably, as a result of their conflict, scientific literacy has been compromised among United States and European public school students. The history of this struggle over science curricula is very complex and many misrepresentations and half-truths have been asserted on both sides. As a result, the history of this conflict is the logical place to begin my summary of this research.

Although it seems like a recent challenge, science education in United States public schools has been beleaguered for more than a century by a continuous series of curriculum challenges posed by fundamentalist evangelical Christians. These individuals seek to reinterpret or completely supplant several different scientific disciplines, including archeology, biology, paleontology, physics, and astrophysics, and teach "creation science" in their places (Answers in Genesis, 2012; Numbers, 2002; Skehan & Nelson, 2000). Creation science was advanced as a means to explain nature and appeared as a pseudo-science that markedly lacks an empirical methodology, but which represents an attempt to explain all physical phenomena in light of (a) the 6-day (i.e., literal 24-hour days) creation account depicted in the Book of Genesis; (b) Noah's Flood; and (c) the notion of a young Earth, usually less than 10,000 years from origin—all of which they believe in light of their hyper-literal reading of scripture (Larson, 2003; Scharrer, 2011).

Creationists reject the idea that the biblical authors, particularly the Old Testament authors, often made use of allegorical, symbolic, figurative, metaphoric, mystical, spiritual, and even poetic language to convey multilayered and profound truths (Jurgens, 1970). Conversely, creationists interpret scripture through a hyper-literal sense, they have defined as follows: "1) the Bible is verbally inspired; 2) inerrant in its every reference, statistic, and quotation; and 3) as written down on the original autographs" (Sandeen, as cited in Patheos, 2012, The Role of Princeton Theology section, para. 2). The creationists' hyper-literal reading of scripture inevitably led to their rejection of the theory of evolution, along with any other scientific findings that contradict their doctrine of *special creation* (Answers in Genesis, 2012; Skehan & Nelson, 2000).

The United States courts have issued several rulings prohibiting the teaching of creation science in public schools, specifically citing the absence of an empirical methodology associated with creation science, but creationists remain undaunted and continue their campaign against the conclusions of modern science (Answers in Genesis, 2012; Larson, 2003; NCSE, 2012; Numbers, 2002). This ongoing campaign is what has caused the tension and confusion in many science classrooms, which are often at the mercy of elected officials pushing their own agendas.

Several different groups have opposed the creationist agenda through the course of the last century, including various teacher organizations, several local school boards, science teacher organizations, the Catholic Church, and several mainline Protestant denominations, and so forth (Larson, 2003; Skehan & Nelson, 2000). From a historical point of view, however, the most vocal opponents of creationism have been Darwinists (Larsen, 2008). Regrettably, over the course of the conflict, Darwinists have frequently ventured beyond the limits of science by proposing that Darwinism somehow disproves the existence of God (Dawkins, 2006; Harris, 2004) and by characterizing the creationists' opposition to evolution as proof of a much more general conflict between religion and science (Stark, 2003). These types of assertions have only served to exacerbate the situation, and the historic record documents the repercussions of these views.

As discussed in Chapter 4, the notion of a general opposition to science by religion is a claim that originated during the Age of Enlightenment in the 18th century (Schaefer, 2011; Stark, 2003). At that time, several members of the European intellectual elite proposed that the only reliable truths are those truths that are derived through empirical means. Thus, Enlightenment thinkers not only called all religious belief into question, but went even further and claimed that science and religion are not only opposed, but at war (Russell, 2002; Wilson, 2002). During and long after the Enlightenment era, a series of myths were disseminated as "proof" that science and religion are in inexorable conflict (Draper, 1874; Pernoud, 1977/2000; White, 1896). Regrettably, these science myths have so often been broadcast through the popular media, reiterated in United States and European textbooks, and repeated by classroom science teachers, that they have now permeated the public consciousness to the point that they are regarded as "common knowledge" (Pernoud, 1977/2000; Singham, 2007; Woods, 2005). Many examples of the commonly repeated myths concerning science and religion are provided in Chapter 4.

The research questions within this dissertation were designed as a means to address each of the above listed problems confronting education, particularly those challenges related to science curriculum and pedagogy. In relation to the historical relationship of faith and science, the creationist position is a relatively recent phenomenon, in that it opposes the traditional Christian understanding of creation and the workings of nature (Jaki, 1990; Woods, 2005). As a result, the creationist movement and its implications for education were addressed after first analyzing the historical development of empirical science itself, which included many false starts and failures before finally receiving the theological rationale required to initiate a systematic studying of nature. The historical antecedents detailed in Chapter 4 above, provided background and context for each of the research questions herein and enabled reliable conclusions to be drawn from the record.

Central Research Question Discussion

The central research question was as follows: What additional facts and insights may be learned through a thorough exploration of the historical relationship of faith and science, in light of current challenges confronting educators?

This exploration of the historical relationship of faith and science has revealed that faith provides the context or prism through which people, even entire civilizations, view the world (Hannam, 2011). One's theological outlook provides a framework or worldview that allows some possibilities and disallows others – even possibilities concerning nature itself. This research has shown that the theological presuppositions of every pre-Christian and post-Christian civilization of record, essentially discounted the idea of an intelligible, predictable universe, but believed the universe to be unpredictable and controlled by a pantheon of gods or a comprised divinity itself (Jaki, 2000; Woods, 2005).

For example, although ancient Egyptians possessed the technical skills to build the pyramids, they lacked a paradigm in which to develop scientific theory (Jaki, 2000). Similarly, the decimal system and notation are undoubtedly India's most important single contribution to science, insofar as the development of scientific methods would have been considerably delayed had scholars of the Middle Ages had to rely on cumbersome Roman numerals. However, not only did India fail to follow up on their greatest contribution to science, they also left no record as to how, where, or for what purpose they developed the first decimal system (Plofker, 2008). Likewise, the ancient Chinese were immersed in Eastern pantheism, which essentially precluded the need and desire to investigate the workings of nature (Hannam, 2011; Jaki, 2000; Woods, 2005). As a result, the ancient Chinese discovered that a needle floating in liquid always pointed north, but the profound usefulness of such a device seems to have escaped them and they retained the device as a novelty for children (Hannam, 2011; Magnetic Lab, 2013). But within a few decades of the missionaries return home with the magnetic needle, ships all across the European continent were equipped with navigational compasses (Hannam, 2011). Unfortunately, the histories of ancient civilizations abound with similar examples of discoveries and advances that held great potential, but which were never followed up on and brought to culmination (Jaki, 1990; Stark, 2003).

The Christian faith proved to be the exception, in that Christian theology engendered a markedly different worldview: a worldview that encourages an earnest examination of nature (Jaki, 2000; Stark, 2003; Woods, 2005). Christian theology holds an unswerving belief in: (1) an Intelligent Creator, Who created a rational universe at a singular point in time; (2) the idea that all people are created in the image and likeness of God; (3) and who are thus, endowed with intellect that renders them capable of discovering the workings of God's creation (Hess & Allen, 2008; Jaki, 2000; Royal, 2006; Stark, 2003; Woods, 2005). The realization that the cosmos itself is rational and orderly was a decisive realization that had seemingly escaped all civilizations of record, until the arrival of the Christian faith. As a result, empirical science first took form and progressed within Christian Europe, which provided the irreplaceable theological, institutional, technological, and theoretical framework necessary for the development and advancement of science (Hannam, 2011). Thus, the history of science exhibits a fascinating relationship between faith and science, wherein theological beliefs can provide a fertile ground or stifle the very idea of science (Jaki, 1990).

History never stands still and as it evolves, many ideas – even universally accepted ideas – are modified, and oftentimes replaced. Christian theology has a 2,000 year history and particularly since the Protestant Reformation, Christian doctrine has been reinterpreted and understood differently by many different groups. This research has illustrated how traditional Christian theological beliefs concerning the rationality of the universe initially gave rise to and fostered empirical scientific investigation. Nonetheless, a historically recent innovation in biblical exegesis took its current form in a large segment of late 20th century American Protestantism, which insists on a strictly literal interpretation of the Bible. This literal interpretation of the Bible by millions of

Christians has led to several beliefs that significantly conflict with many conclusions of modern empirical science. Interestingly, this hyper-literal interpretive method utilized by millions of contemporary Protestant Christians has been a mainstay of the Islamic faith for a millennium. Thus, millions of evangelical Christians and Muslims interpret Old Testament scripture literally, which leads them to shared beliefs, such as, the idea that the Earth and entire universe are approximately 10,000 years old, all geological data should be interpreted in light of Noah's Flood (Numbers, 2002), and all living organism were created in essentially their present form approximately 10,000 years ago (Answers in Genesis, 2012; Heneghan, 2011; Horn & Wiedenhofer, 2008; Skehan & Nelson, 2000).

By its nature, science cannot and does not seek to prove or disprove the existence of God because that type of conclusion is simply not a legitimate scientific objective (Skehan & Nelson, 2000). Nonetheless, conflict theorists have often suggested that science, in effect, takes the place of a Creator or at least does away with the need for a Creator (Dawkins, 2006; Harris, 2004). It is true, however, that for many people, several recent scientific discoveries point to an Intelligent Creator. For example, the overturning of Newton's conception of an eternal universe in favor of the Big Bang event (Spitzer, 2010) and the existence of anthropic, life supporting, conditions within the universe (Flew & Varghese, 2007), in the face of the astronomical mathematical odds against such conditions existing (Vilenkin, 2007). Physicists have noted that explosions typically do not produce order and exactitude, but disorder and chaos. In a letter to a friend, Albert Einstein expressed his amazement that the universe comprises anthropic (i.e., life supporting) conditions and exquisite order: "…a priori one should expect a chaotic world which cannot be in any way grasped through thought. . .That is the 'miracle' which grows increasingly persuasive with the increasing development of knowledge" (as cited in Hyper Physics, n.d., para. 4).

Conflict theorists claim an inherent conflict or irreconcilable differences exist between faith and science (Draper, 1874; White, 1896). In reality, the relationship of faith and science is not growing fainter with the advancement of science, but new questions are arising (Spitzer, 2010). For theists, God does not represent that part of science that has not yet been discovered, as many advocates of the conflict thesis claim. Rather, theists marvel at the magnificence of creation, as empirical science increasingly reveals the exactitude, patterns, and beauty of the universe (Flew & Varghese, 2007).

It is true, however, that modern-day proponents of intelligent design theory do, in effect, argue for a God of the gaps, as they reason, "I don't know how this thing works or originated, so God must make it work by a direct miracle" (Shea, 2013, para. 3). Whereas, Christian intellectuals like the 13th century intellectual, Thomas Aquinas, have traditionally been inspired by the lawfulness of nature, not exceptions to those laws. The laws of nature present in the universe govern time, space, matter, and energy, and together these laws make science possible (Shea, 2013). For traditional theists, then, God is not found in the gaps in scientific discovery, but is indicated in the beauty and order within nature itself – a beauty and order progressively made known through science.

The significance of the central research question for education pertains to what constitutes appropriate science curricula. The history of the commencement and advancement of empirical science demonstrates that Christian theology played a pivotal role in first prompting the empirical investigation of nature. Additionally, Christian intellectuals (i.e., almost all Catholic clergy) were virtually the only people engaged in scientific investigation for close to a 1,000 years. Moreover, the Catholic Church provided the necessary infrastructure and resources (i.e., within the monastic and university systems) required for the steady progress of science. In short, the historical relationship of faith and science demonstrates that the conflict theory, together with its associated myths and misinformation concerning the Church's supposed opposition to science, is unsustainable. Educators and their students will benefit from curriculum that finally abandons the tenants of the conflict thesis and its corresponding falsehoods, in favor of a genuine study of science.

First Subquestion Discussion

What significance, if any, can be attributed to faith in the development of science, during the period between the fall of the Roman Empire through the Renaissance?

The significance of faith in the development of science in the historical period between the fall of the Roman Empire and the Renaissance is extremely important because that is the precise period in human history when empirical science first took form and then steadily progressed (Hess & Allen, 2008; Jaki, 2000; Royal, 2006; Stark, 2003; Woods, 2005). Moreover, the development of the empirical methodology and subsequent development of science in the period commonly known as the Dark Ages, invalidates the common historical caricature of the 1,000 year period between the fall of Rome and the Renaissance as, in effect, an interruption of human progress (Hannam, 2011; Pernoud, 1977/2000; Woods, 2005).

For example, in this dissertation, I traced the development of the heliocentric model, which involved the abandonment of Aristotelian physics, the merging of mathematics with physics, prodigious progress in mathematics, and development of theory, which were already in place when Copernicus began his studies. But even before any of the previous achievements were recognized, the great works of Western civilization had been painstakingly preserved within the European monastic system and the Church sponsored university system was flourishing (Hannam, 2011; Jaki, 1990; Woods, 2005). Consequently, the historical relationship of the Christian faith to science is one of cooperation, not conflict.

Significantly, the majority of the instances of so-called Church antagonism toward science are said to have occurred in the historical period between the fall of Rome and the Renaissance (Numbers, 2009; Woods, 2005). This historical survey of the period has established that, contrary to the conflict thesis, the period between the fall of the Roman Empire and the Renaissance stands out as one of great human progress and not nearly as metaphorically dark as popular opinion and many school textbooks portray (Hannam, 2011; Pernoud, 1977/2000). The science myths are inventions of people who lived in later eras, who, for a variety of reasons, sought to emphasize their own accomplishments and those of their peers, while diminishing the accomplishments realized within previous eras (Hannam, 2011; Woods, 2005).

Chapter 4 described how and for what reasons the various myths and misinformation concerning the medieval Church's alleged suppression of science took form. Protestant rulers were often motivated to solidify their power by discrediting

Catholicism in general, which led to the creation of several of the science myths. Later, Age of Enlightenment thinkers, who sought to overthrow the power of the Catholic Church, made use of science myths to demonstrate the Church's opposition to societal progress (Smollett et al., 1905). As a result, incredible stories began to circulate in various public spheres, which eventually became "common knowledge" in the public mind. A few examples are: Columbus and the flat Earth; the "silly pope" who tried to pray away Halley's Comet from the Earth; and the general claim science was unable to advance and prosper until the Protestant Reformation of the 16th century successfully stripped the Catholic Church of its power and influence, and so forth. These and similar legends related to the Catholic Church's suppression of or ignorance of the truth were invented by individuals and groups, who had an interest in discrediting the Church and its various accomplishments (Knight & Lomas, 2001; Pernoud, 1977/2000; Stark, 2003; Wiker, 2011; Woods, 2005).

By far, however, the most famous and often repeated of such myths, concerns the Galileo affair of the early 17th century (Numbers, 2009; Pernoud, 1977/2000). The leading Enlightenment figure, Voltaire, summed up the Galileo affair in 1728: "The great Galileo, at the age of fourscore, groaned away his day in the dungeons of the Inquisition, because he had demonstrated by irrefragable proofs the motion of the earth" (Smollett et al., 1905, p. 167). In 1980, Carl Sagan, lamented that Galileo had languished "in a Catholic dungeon threatened with torture" for his "heretical view that the earth moved about the sun" (as cited in D'Souza, 2008, p. 101). Harris (2004) wrote of the Christian tradition of "torturing scholars to the point of madness for merely speculating about the nature of the stars" (Harris, 2004, p. 105). Apparently, for the sake of fairness, Jakosky (1988) asserted that "Copernicus's views were not embraced by the church" and added "the history of his persecution is well known" (as cited in D'Souza, 2008, p. 101).

As demonstrated in chapter 4, the historical record provides a very different picture of the relationship between the Catholic Church and scholars during the period in question. For example, for many years the Vatican actually prodded Copernicus to publish his heliocentric theory before he finally relented and published his life's work (Woods, 2005) and when he did finally publish his theory, he dedicated the work to the reigning pope (Hess & Allen, 2008). In the more than half of a century between Copernicus's death and Galileo's career, the heliocentric model was studied throughout the Catholic universities of Europe and the Church voiced no objections to heliocentrism in that period. In contrast to the common perception, the first and most forceful objections were not made by Vatican officials, but by the leading Protestant Reformers, Luther, Calvin, and their disciples (Hess & Allen, 2008; Wiker, 2011). Protestant leaders repeatedly expressed contempt for the Copernican model because it contradicted their interpretation of scripture. Thus, mainly in response to Protestant accusations that the Catholic Church ignored the Bible, the Vatican eventually censored Galileo. Galileo was told he could continue to write of and teach the heliocentric model as a theory, but not teach heliocentrism as fact because it had not yet been confirmed (Woods, 2005).

The history of the development of science in the period between the fall of the Roman Empire and the Renaissance, demonstrates that: (1) the parameters of the empirical methodology were first developed in the period; (2) the theological underpinnings that gave rise to the systematic study of nature began to prosper; (3) the institutional, technological, and theoretical infrastructure necessary for the advance of science were made available within Christian Europe; and (4) the myths associated with the conflict thesis, which purports faith and science are in inexorable conflict, are inventions of post-Protestant Reformation and Age of Enlightenment polemicists (Gerard, 1909; Hannam, 2011; Pernoud, 1977/2000; Wiker, 2011; Woods, 2005). It is clear, then, that empirical science initially took form and began to advance in the period between the fall of the Roman Empire and the Renaissance and a truthful accounting of the historical facts supports the education process on many levels.

Second Subquestion Discussion

What importance does the historical origins and progress of science hold in informing the continuing creationist versus Darwinist conflict within education?

The significance of the origins and progress of science in relation to the creationist versus Darwinist conflict within education is significant in that the histories of both movements provides critical background for educators, as they navigate the complexities of the conflict. For example, education professionals should benefit from understanding that the creationist movement is a very recent historical phenomenon in the long history of the Christian faith and that, although creationists are often outspoken in their efforts to advocate for their doctrine, they are far from representative of Christianity as a whole (Sandeen, 1967).

Creationists hold to a hyper-literal reading of the Bible, which informs their fundamentalist beliefs concerning creation (Skehan & Nelson, 2000). It was especially interesting to note, given the juxtaposition of these two religions in the world at the moment, that Muslims interpret the first five books of the Bible in the same hyper-literal sense, and as a consequence, are also engaged in vigorously advocating for the creationist doctrine (Heneghan, 2011). Nonetheless, Christian and Muslim Creationists have not yet formed a workable relationship and remain uncomfortable allies in their quest to overturn the conclusions of modern science (Answers in Genesis, 2010). The doctrine of *special creation* forbids any notion of a gradual development of life forms (i.e., the evolution of life). Thus, fundamentalist evangelical Christians rejected Darwin's evolutionary theory from the inception of their movement (Sandeen, 1967) and fundamentalist Muslims joined the anti-evolution movement more recently (Answers in Genesis, 2010).

The history of Darwinism also raises potential concerns for educators. Darwin first published his theory in his 1859 work *The Origin of Species by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life*. Much to his surprise and dismay, many Christians received his theory with great enthusiasm, as they viewed it as an elegant explanation of God's creative work (Stark, 2003). Soon, however, with the publication of additional works in further explanation of his theory by Darwin and his associates, many people, including many Christians, became increasingly troubled by his thesis. Of particular concern was the appalling degradation of various groups of people in light of his theory, such as, women, people of color, the Irish people, the labor class, and the mentally disabled (Darwin, 1868; Darwin, 1871; Darwin, 1874; Darwin, 1882; Vogt, 1864). It is not difficult to imagine how a member of any one of these groups would be repulsed by Darwin’s analysis and explanation of the implications of his own theory.

Additionally, although not commonly discussed, many within the scientific community, including some Neo-Darwinists, have questioned whether or not Darwin’s specific evolutionary mechanism can account for the evolution of and incredible diversity of life forms (Gould, 1980; Stark, 2003). More specifically, the apparent absence of gradualism in nature, wherein species develop over geological ages and the apparent lack of missing links, have been problems for Darwin’s theory from the beginning and have become more pronounced with increasing data collection (Stark, 2003). Others have proposed alternative evolutionary mechanisms, but have generally been dismissed by the scientific community (Depew & Weber, 2011). However, in 2013, a group of researchers published research results, in which they documented the evolution of blind cavefish in Mexican caves, through a process entirely outside the parameters of Darwin’s theory (i.e., natural selection; and common descent; coupled with random mutation) (Kenney, 2013).

It is the nature of scientific theory that a great number are eventually overturned, the majority of others are revised after further research, and only a comparative few come to be regarded as scientific orthodoxy. It is a curious fact of history that Darwinists have exhibited a particular tenaciousness in defending every aspect of Darwin's theory - even in light of any evidence to the contrary (Stark, 2003). For example, the celebrated Darwinist, Gould (1980), wrote of the disrespectful treatment shown to one of his predecessors after he admitted the lack of fossil evidence in support of a central tenet of Darwin’s theory (i.e., gradualism in nature).

Two factors may account for the Darwinists utter unwillingness to admit any of the theory's apparent shortcomings. First, they may be unwilling to show any sign of weakness in the midst of their long-standing struggle with creationists. For example, Dawkins accused his Darwinist colleagues, Eldredge and Gould, of giving "spurious aid and comfort to modern creationists" because "if a reputable scholar breathes so much as a hint of criticism of some detail of Darwinian theory, the fact is seized upon and blown up out of proportion" (as cited in Stark, 2003, p. 177). Dawkins' proposed solution was to keep any apparent deficiencies of the theory as a sort of "trade secret" (as cited in Stark, 2003, p. 177) among Darwinists. The second reason Darwinists have adopted a "bunker mentality" in protection of the theory may be attributable to their general desire that Darwin's theory will somehow supplant or at least show the pointlessness of religion. Examples abound of Darwinists, from the beginning up to the present, expressing their contempt for religion and religious sentiment (Dawkins, 2006; Harris, 2004; Royal, 2006; Stark, 2003).

In conclusion, in response to the creationist versus Darwinist conflict, educators and legislators must continue to oppose the creationist agenda that is so strenuously advocated in various settings by both evangelical fundamentalist Christians (Answers in Genesis, 2012) and fundamentalist Muslims (Heneghan, 2011), if scientific research is to continue to benefit society and address challenges pressing on society. Creation science cannot be characterized as empirical science, but rather, as an attempt to explain natural phenomena through the lens of a religious doctrine (Mahta, 2012). Moreover, when teaching students the theory of evolution, educators should not fail to disclose both the positive and negative aspects of Darwin's theory, including its apparent inconsistency with the fossil evidence, as well as the ramifications for different groups of people in accord with Darwinism, as expressed by Darwin himself (Darwin, 1871; Darwin, 1874; Darwin, 1882) and his disciples (Vogt, 1664). A multitude of people worldwide are committed evolutionists, but reject many aspects of Darwin's particular theory. School curriculum that fully discloses the facts concerning both creationism and Darwinism would serve to illuminate both teachers and their students and in the end, may eventually resolve the conflict through the educational process.

Interpretation of Findings

Educators in 2014 are confronted with allegations, wherein Christianity is said to be in continuous conflict with science – even opposed to science (Royal, 2006; Stark, 2003; Woods, 2005). The conflict thesis has its roots in the Age of Enlightenment (Pernoud, 1977/2000), but is incessantly reiterated by its modern-day proponents (Dawkins, 2006; Harris, 2004). Educators should be made cognizant of the fact that through the centuries, the conflict thesis has amassed a series of myths that purportedly prove Christianity's contempt for science and these myths are presented as "facts" within modern textbooks (Pernoud, 1977/2000; Singham, 2007).

My examination of the historical relationship of faith and science, in light of current challenges facing educators, has demonstrated how theological ideas profoundly shape and inform the outlook or worldview of both individuals and even entire civilizations (Hannam, 2011; Jaki, 1990; Stark, 2003; Woods, 2005). This research has revealed how religious beliefs present in every other pre-Christian and post-Christian culture, actually stifled the very idea that investigating natural phenomena is sensible. Christianity alone provided the theological underpinnings that led to a serious, systematic investigation of nature. The Christian beliefs in an Intelligent Creator of a rational universe, in human beings formed in the image of that Creator and endowed with intelligence, finally provided sufficient justification for the methodical and continuous investigation of nature (Jaki, 2000; Woods, 2005).

The relationship of faith and science is then, directly related to worldview or one's conception of the nature of the universe (Hannam, 2011; Jaki, 1990). A faith perspective can produce a worldview hospitable or inhospitable to the investigation of nature. It is the case that the ancient Christian faith first provided the requisite worldview that prompted people to seriously investigate the cosmos (Hannam, 2011; Jaki, 2000; Woods, 2005). Now however, that worldview, which presupposes the rationality of the universe, is simply taken for granted by millions worldwide (Hannam, 2011), but the rationality of the universe was never seriously considered until the onset of Christianity (Hannam, 2011; Jaki, 2000). The exquisite order of the universe becomes clearer, as the various scientific disciplines push the boundaries of discovery further in the 21st century (Spitzer, 2010).

The challenge for administrators, teachers, and curriculum specialists, is to develop and implement curriculum and lesson plans that reflect authentic science history–that are not shrouded in myths and misinformation that confuse the issues. The history of science and its historical connection to the Christian faith is far more interesting and compelling than the time-worn stories of the conflict thesis. Students would greatly benefit from curriculum that abandons the conflict thesis myths and replaces them with the truth regarding the rise and progress of science.

The first sub-question herein, enquired as to the significance, if any, that can be attributed to faith in the development of science, during the period between the fall of the Roman Empire through the Renaissance. This research has revealed that the empirical science methodology was first conceived within that historical period and science soon prospered (Hannam, 2011; Lindberg, 1992). Incredible progress in science was recognized between the fall of Rome and the Renaissance, principally because the Church in Europe provided the essential theological, institutional, technological, and theoretical infrastructure needed for the advance of science (Hannam, 2011; Woods, 2005). In light of the misinformation reported by both sides of the creationists versus Darwinists battle raging on public schools, the current relationship between science and religion does not seem as positive.

Prior to the fall of the Roman Empire, Christian thinkers engaged in intense debate with their pagan counterparts (Siegfried, 1908; Spitzer, 2010), concerning both the rationality of the cosmos versus a disordered, unpredictable cosmos, and an eternal universe versus a universe created *ex nihilo* (i.e., *out of nothing*). The Christian understanding of a rational, predictable universe, created at a singular point in time, ultimately prevailed, and, as a result, empirical science significantly advanced in the intervening years between Rome's collapse and the advent of the Renaissance (Lindberg, 1992; Woods, 2005).

The second sub-question addressed how the historical origins and progress of science could inform the ongoing creationist versus Darwinist debate. The history of scientific development unequivocally demonstrates that the creationist doctrine and related movement is a very recent phenomenon in the history of both Christianity and science (Sandeen, 1967). The notion of interpreting the Bible through a literal lens was a mark of the 16th century's leading Protestant Reformers, Luther and Calvin, who both scorned Copernicus's heliocentric model (Hess & Allen, 2008; Hagen, 1908). However, the idea of interpreting the Bible in a hyper-literal sense began in late 19th century America within Protestant Christianity. At that time, a group of ministers known as the Princeton Calvinists devised the hyper-literal interpretive method, which informs the creationist doctrine (Sandeen, 1967). Muslims, also read scripture through a hyper-literal lens and have also become formidable advocates for the creationist agenda in both the United States and Europe (Heneghan, 2011).

This research has provided educators and others with insights into the creationist movement, as discussed above, as well as Darwinism. Although Darwinism is commonly presented as an established theory, some within the scientific community and even some Neo-Darwinists, question its validity (Depew & Weber, 2011; Gould, 1980; Stark, 2003). The fossil record in Darwin's day and still at present, has failed to substantiate the gradual development of living species, which is a grounding principle of his theory (University of California Museum of Paleontology, 2011).

The apparent absence of gradualism in nature should not, however, be construed as evidence against evolution itself because the evolution of life is a substantiated fact.

DNA evidence has confirmed that Darwin's concept of common descent, wherein all living organisms share common ancestry, is correct (Ayala, 2010; Behe, 2007; Horn & Wiedenhofer, 2008). Further, the existence of simple life forms in the oldest geological strata versus more complex forms in more recent strata, also confirms the evolution of life forms (Ayala, 2010; Muckermann, 1909; Horn & Wiedenhofer, 2008; Skehan & Nelson, 2000; Wiker, 2009).

The question some scholars are asking concerns whether or not Darwin's proposed evolutionary mechanism can adequately explain the evolution of life and the tremendous diversity of living organism found on Earth or if another evolutionary mechanism may be found that can better explain the evolution of and diversity of life forms (Depew & Weber, 2011; Gould, 1980; Stark, 2003). For example, the discovery associated with the evolution of blind cavefish in Mexico in 2013, as noted above, suggests an alternative evolutionary mechanism may better explain the development of life forms (Kenney, 2013; Rohner et al., 2013).

Finally, it is incumbent upon educators to offer students a comprehensive account of Darwin's theory, which includes the fact that common descent has been substantiated (Ayala, 2010; Behe, 2007; Horn & Wiedenhofer, 2008), along with the apparent discrepancies between his theory of gradualism versus the reality of the fossil evidence (Stark, 2003; University of California Museum of Paleontology, 2011). Additionally, students deserve a full accounting of how Darwin and his closest collaborators interpreted and explained his theory, in light of women, people of color, various cultural groups, and even the mentally impaired (Darwin, 1871; Darwin, 1874; Darwin, 1882; Vogt, 1864).

It may be said that students are regularly taught a sterilized version of Darwinism, one which neglects to mention the considerable deficiencies in his scientific method and utterly ignores his own scandalous conclusions regarding various people and groups, as a natural consequence of his theory. Textbooks filter out most of Darwin's observations and statements and replace them with generalizations of his theory. For example, one would be hard pressed to find a textbook that reports Darwin's observation that at birth the hands of English laborers are larger than the hands of the gentle class; his observation that United States sailors had shorter arms than United States soldiers, which he reasoned may be attributable to increased use; or his numerous assumptions regarding "savages," such as, assuming "savages" are evidence of a lower state of evolutionary development than that achieved by white Europeans (Darwin, 1871). Students can only make informed decisions when they are in possession of all of the available information associated with an issue. Specifics of Darwinism and the complete lack of a scientific methodology associated with creationism are no exceptions.

Relation to the Theoretical Framework

The role of a theoretical or conceptual framework in research is to guide the research process (Laureate Education, Inc., 2010f) and is often utilized when "something is known conceptually about the phenomenon, but not enough to house a theory" (Miles & Huberman, 1994, p. 17). The theoretical framework employed within this research is grounded in the realization that historical literacy enhances pedagogy and learning (Brown, 1987).

Historical literacy provides the necessary background and context for the broad understanding and interpretation of past events (Brown, 2007). This research was theory-driven (Maxwell, 2005), insofar as the theoretical framework grounded in the literature has served to emphasize the need for historical literacy, which is in accordance with the historical approach methodology. History as a hermeneutic for education can foster historical literacy among students. In the context of this research, historical literacy concerns the historical relationship of faith and science, which can enable students and educators alike to form intelligent opinions and make informed decisions about the myriad of issues in relation to the relationship of faith and science.

Trustworthiness and Limitations

No procedural adjustments were required in order to ensure the credibility, transferability, dependability, and confirmability of research findings. That is, this research was conducted in keeping with the research protocol, as previously described in chapter 3. A credible representation of the historical case emerged following extensive data collection and analysis of the germane historical facts (Heck, 2004). Research conclusions were derived from a convergence of antecedent probabilities that were logically derived from the evidence (as cited in Miles & Huberman, 1994; Newman, 1870). The result is that the reconstructed historical narrative is the result of arguments developed from the research data, through which the historical case is presented using connected statements, comprised of logically valid inferences, in which the substantive components are objectively correct (Fielding & Fielding, 1986).

Implications for Social Change

The debate over the nature of the relationship of faith and science has a very long history (Draper, 1874; Stark, 2003; White, 1896) and is notable for an increasing polarization between groups (Dawkins, 2006; Harris, 2004). The long-standing conflict over science curriculum content endures within local public school districts, state legislatures, the public domain, and within the United States courts (Larson, 2003; NCSE, 2001; Numbers, 2002). The discipline of education has been subject to the deleterious effects of the ongoing legal and public conflict, as the public schools are the primary battleground where the dispute plays out (DeWolf, Meyer, & DeForrest, 1999; Larson, 2003). Many administrators, curriculum development specialists, and teachers are unsure of where to turn for answers concerning what is acceptable science content for the classroom and how best to present that content (Skehan & Nelson, 2000). Even the commonly recognized acceptable content seems to be an issue, as well.

To further confuse the issues related to faith and science, through the course of centuries, commonly repeated science myths have successfully permeated science curriculum content, which classroom teachers, usually unknowingly, continue to teach as facts (Boorstin, 1983; Stark, 2003). The conflict over science curriculum in public schools is regularly reduced to “science versus religion” or “science versus faith” terms (NCSE, 2012; Larson, 2003; Skehan & Nelson, 2000; Stark, 2003). The ultimate concern, however, remains the students, who, in addition to being taught myths that advance the notion of a conflict between faith and science, are frequently being compelled to choose between what they often perceive as their most personal, cherished, and safe, cultural experiences. Many students are forced into an emotional dilemma, wherein the ongoing conflict forces them to choose between their family values, their educational experience, and often, their religious faith tradition (Scheitle, 2011; Zimmerman, 2002).

The hope is that this historical survey has provided a more clear understanding of the origins and progress of science, particularly in light of how faith played a significant role in that history. Educators and their students will undoubtedly benefit from understanding how theological beliefs converge to form a worldview that permits some possibilities and prohibits others – even possibilities within nature. Thus, Christianity provided a fruitful theological understanding that was beneficial to and encouraged the study of nature, whereas, all other faith traditions of record produced theological ideas that presumed an unpredictable, disordered, unknowable universe.

It is the case that creationists and their Darwinist adversaries have taken up entrenched positions that are very often uninformed, but which both sides attempt to bolster with falsehoods and myths (Ham, 2004; Stark, 2003). Many of the facts associated with their respective positions are often uncomfortable and seldom published (Sandeen, 1967; Stark, 2003). Education is ideally suited to see through myths and disclose facts, but in 2014, the discipline of education finds itself in the midst of a centuries-long conflict that is laden with recurring falsehoods and ambiguities on both sides. Still, in relation to science curriculum and pedagogy, many aspects of Darwin's theory hold value and have been proven accurate, whereas, creation science has no place in the science classroom.

The hope is that this comprehensive study will assist in broadening the understanding of the decision-makers, and thereby, ease the persistent cultural clash over science curriculum and pedagogy (Pecora, 2007; Scheitle, 2011; Zimmerman, 2002). In the final analysis, students should be taught science in science classrooms – not a religious or philosophical ideology. Significant social change can be attained if educators are freed to teach science, apart from ideology and myth, and this study is directed toward assisting to achieve that end. Unfortunately, no previous study is available to inform that conversation.

Recommendations for Actions

The discipline of education, particularly science education, has been embattled by three significant factors that continue to disrupt learning in public schools: (1) the century and a half long creationist versus Darwinist clash over teaching evolution in public schools (Le Beau, 2007; Larson, 2002; Skehan & Nelson, 2000); (2) centuries old myths related to science and faith that continue to be taught as "facts" within public schools (Numbers, 2009; Pernoud, 1977/2000; Wiker, 2011); and (3) the post-Protestant Reformation and Age of Enlightenment notion that faith and science are in conflict (Draper, 1874; Hess & Allen, 2008), which comprises several errors commonly taught in public school classrooms and which has now largely permeated the public consciousness (Pernoud, 1977/2000; Wiker, 2011; Woods, 2005).

The following corrective action steps are recommended, as a response to the above listed educational disruptions:

First, curriculum specialist should adopt research procedures, wherein primary sources are given priority over secondary and tertiary sources. Particularly in relation to the history of science, textbook authors should eliminate the common practice of simply adopting previously published information into revised textbooks without first examining the historical record (Pernoud, 1977/2000; Numbers, 2009). Examination of the original source materials will provide curriculum specialists with accurate information that has not been tainted by opinions and translations by subsequent generations.

Second, education administrators should familiarize themselves, their staffs, and teaching professionals under their supervision, with the series of court rulings, wherein United States federal courts have: (1) ruled against the creationist agenda; (2) identified creationism as a religious doctrine; (3) and forbidden the teaching of "creation science" in public schools on the grounds that "creation science" is a religious doctrine and lacks any discernable methodology (Larson, 2003; NCSE, 2012).

Third, in addition to being informed regarding the prohibition against teaching "creation science" in public schools, teachers should teach the most up-to-date and accurate information available in relation to evolutionary science. That is, curriculum specialists and classroom teachers should be diligent in their efforts to convey much more than the superficial treatment of Charles Darwin's theory of evolution than what seems to be typically being taught in 2014. For example, an accurate accounting of Darwin's theory should also include an honest accounting and assessment of Darwin's theory in light of the existent fossil record, along with Darwin's own statements in explanation of his theory, in light of its cultural and social implications for various groups within society (Darwin, 1871).

In keeping with the stated objective that this research will assist education administrators, curriculum specialists, and classroom teachers, to better understand the historical relationship of faith and science, as well as the creationist versus Darwinist conflict; the aim is to share this research with the scholarly community. Aside from the publication of this dissertation, it is anticipated that this information will be disseminated, at least in part, through publication of future articles within scholarly, peer-reviewed journals, and presented at professional development seminars and conferences, such as, the National Science Teachers Association (NSTA) Conference, various state and national science teachers organizations, Educators Professional Development (EPD) conferences, and other academic venues.

Recommendations for Further Study

Additional research is needed into the creation science phenomenon. The absence of any identifiable empirical methodology present in creation science, beyond discounting any conclusions of modern science that conflict with the creationist doctrine, is of particular concern to education professionals. For example, this dissertation has revealed that both fundamentalist Christian and Islamic creationists have each produced forms of creation science with associated textbooks (Davis & Kenyon, 1993; Heneghan, 2011). Education professionals would be advised to familiarize themselves with the various similarities and differences in the Christian and Islamic versions of creation science. Additional research into the current manifestations of creation science could further illuminate its deficiencies, irrationalities, and religious and political agendas, as it is being imposed on United States and European public schools in 2014.

A comprehensive study identifying measurable outcomes related to student learning, as a result of teaching students the series of myths an misinformation surrounding the relationship of faith and science would be informative for educators. It is accepted that historical literacy informs and improves educational practice, so the level at which historical literacy is undermined by the teaching of myths and misinformation in place of facts must have consequences for students, particularly as they advance to college.

Several other historical threads that relate to the historical relationship of faith and science could be traced and analyzed by future scholars. Also, important work could be pursued which relates to the relationship between science and public policy. For instance, significant questions currently surround the debate over global climate change, which future scholars will undoubtedly address.

Reflections on Researcher's Experience

It is the case that in the course of a study, every researcher approaches the topic with his/her own preconceived notions and biases. Preconceived notions and personal predispositions regarding a topic do not, by themselves, discredit a study. If that were the case, no research could be judged credible. My experience and preconceived ideas concerning the research subject matter can be characterized as both individual and shared perceptions. On an individual level, it should be noted that I am of the Catholic faith. On a communal level, prior to getting involved in this research, I possessed a very common understanding of the history of science: common in the sense that my sense of the subject was very similar to that shared by millions of 21st century Westerners, insofar as my perceptions were tainted by a series of myths regarding the history of science.

I had a vague notion that the ancient Greeks invented science before learning was severely stalled and much of it lost during the Dark Ages. I took it for granted that the universe itself is rational, orderly, predictable, and governed by the laws of nature, as well as the fact that human beings are capable of discovery and learning about natural phenomena. I was also, of course, aware that ancient civilizations never developed science – at least not science of any significance, but also never seriously pondered as to why ancient civilizations never developed science.

In spite of being Catholic, I accepted my teachers' assertions and the popular sentiment regarding such ideas as: the Roman Catholic Church condemned Galileo for saying the Earth revolves around the Sun; Columbus and his crew thought they might sail off the edge of the flat Earth; the Catholic Church seriously hindered academic freedom in the Middle Ages; the medieval Church was distrustful of science and scientists; and during the Dark Ages, little or no progress, scientific or otherwise, was made.

I took the rationality and lawfulness of the universe for granted and assumed practically everyone else did as well, so was very surprised to discover that the Islamic faith forbids the notion of secondary laws of nature, as an affront to Allah's sovereign will. Just as I was amazed to learn how Islam's rejection of the laws of nature – the basis of empirical science – has impeded development within Islamic nations, even into the 21st century. This discovery was one of many that I made in the course of this research.

As a Catholic, the creationist doctrine was very foreign to me, as I had no inclination to interpret the Bible, particularly the Old Testament, in a literal sense. I was then, very surprised to learn of the extent to which the creationists have been successful in imposing their agenda within United States public schools. In a similar way, as a Catholic, I had no preconceived notion that evolution somehow opposes the biblical creation accounts found in the Book of Genesis. As a result, from a religious point of view, I had no negative view of evolution whatsoever.

This research can logically be divided into three primary segments: (1) how theological ideas act as a powerful lens through which people and even entire cultures view, interpret, and understand the world around them; (2) the initiation and steady advance of empirical science between the fall of the Roman Empire and the Renaissance; and (3) the continuing, now century and a half long conflict between creationists and Darwinists that continues to disrupt public education in 2014. I made noteworthy discoveries in each of these domains, which significantly changed my attitudes and opinions regarding these subjects.

As a result of completing this research, I gained a renewed appreciation of Christian theology, particularly the stark differences that separate Christian theology from all other theologies in relation to the rationality of the universe. The rationality of the universe is largely taken for granted within 21st century Western culture, but that realization was a revolutionary idea 2000 years ago, which the earliest Christians were ridiculed for believing.

The existence of the conflict thesis, which claims Christianity obstructed scientific progress, seems absurd in light of the significant, practically irreplaceable role Christianity played in the history of science. Although, in view of the climate in Europe during the Age of Enlightenment and in the aftermath of the Protestant Reformation, the motivating rationale underlying the conflict thesis itself, are more transparent. Unfortunately, in 2014, several elements of the conflict thesis continue to influence science education in both the United States and Europe. My desire is that this dissertation will help educators as they navigate these often complex and interrelated issues.

I found it very interesting that the creationist movement took its current as a uniquely American Protestant phenomenon (Numbers, 2002), although its roots can be traced to a small group of Plymouth Brethren in England and Ireland during the 1820s. Finally, the specific statements of Charles Darwin, as he described his theory and vision of its implications for society were particularly fascinating to discover, based on what I though I knew of the topic. As is the case in any historical study, to study Darwinism through Darwin's own words is much preferred to learning about Darwinism through secondary and tertiary sources (Heck, 2004; Miles & Huberman, 1994).

Concluding Statement

This research, completed in accordance with the historical approach methodology, involved a comprehensive analysis of the historical relationship of faith and science, in light of challenges confronting educators in 2014. The challenges for education relate to the implications for science education in light of the continuing creationist versus

Darwinist conflict, as well as how the historical relationship of faith and science is understood by educators and conveyed to their students.

Creationists have markedly disturbed United States public education through the last century (Pew Research, 2006), and are continuing their efforts to impose creation science on public schools (Answers in Genesis, 2012; Larson, 2003). In their efforts to oppose the creationist agenda, Darwinists have: (a) historically misrepresented the Christian position concerning evolution by portraying all Christians as creationists; (b) proposed an inherent conflict exists between faith and science (Numbers, 2009; Stark, 2003); and (c) failed to disclose to students any apparent discrepancies in Darwin's particular theory of evolution. Education professionals must continue to oppose the creationist doctrine and agenda at every level and advocate for a full disclosure of Darwin's evolutionary theory, in light of Charles Darwin's own words and rationale.

Empirical science is characterized by a strictly natural explanation of phenomena, apart from religious ideology. Creationism is clearly a religious doctrine, as it is grounded in a specific biblical interpretive method, so cannot be characterized or fallaciously taught as authentic science. In the final analysis, students should be taught science in science classrooms, not a theological doctrine or philosophical ideology and the creationist doctrine continues to compromise that principle. In spite of the common wisdom, there never really was a general conflict between faith and science, so creating one now or professing one exists, seems to be the wrong direction for education.

Students should be informed that the historical relationship of faith and science is very complex and multifaceted. It is the case that the overwhelming majority of faith traditions practiced throughout history do conflict with science, insofar as they deny the rationality of the universe. Christianity proved to be the lone exception in the history of religion. Nonetheless, the Christian contributions in the history of science are routinely distorted by conflict theorists, who claim faith and science are opposed. Similarly, the facts surrounding Christianity's irreplaceable contributions to science have not prevented a group of modern-day evangelical Christians and members of the Islamic faithful from censoring scientific results through a fundamentalist theological lens, which in effect, is the inverse of the methodology characteristic of empirical science.

The ultimate concern is for the welfare of the students in the desks. Several factors converge, which together form considerable obstacles to student learning. The creationist versus Darwinist conflict primarily concerns science pedagogy and curriculum content, but often involves deeper convictions. Culture remains a critical consideration in education curriculum (Zimmerman, 2002) and religious beliefs and perceptions concerning nature are distinct cultural elements that comprise significant aspects of a student's experience (Scheitle, 2011). These important aspects of the conversation should not be lost in the rhetoric or the posturing.

Family values, religious beliefs, and the educational environment comprise three of the most important cultural encounters for many students (Scheitle, 2011; Zimmerman, 2002). The educational process often challenges students' beliefs, values, perceptions, and even deeply held convictions, which can significantly broaden students' insights. Unfortunately, the narrow nature of the creationist versus Darwinist battle has failed to answer the fundamental questions concerning the actual relationship of faith and science.

Moreover, the debate has become stagnant because neither side seems to tolerate dissenting opinions from their own in relation to this topic (Answers in Genesis, 2012; Dawkins, 2006; Harris, 2004; Stark, 2003). In the final analysis, students are relying on their elected officials, school boards, school administrators, curriculum specialists, and classroom teachers, for their classroom education. Their scientific and historical literacy in preparation for college is dependent on good decision making by others. Hopefully this research will be of value in that decision making process.

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Curriculum Vitae

Professional Profile

My doctoral research encompasses a wide range of subject matter related to education and the sociological sciences. My teaching experience includes university level instruction for Regis University and within the University of Idaho's College of Education, as well as involvement working in elementary and secondary education. I possess extensive experience working with students from a variety of cultures, backgrounds, cultures, and nations, and also college student-athletes. Lastly, I am very proficient and comfortable with distance education, having earned both my Master's degree and Ph.D. in the virtual environment.

Education

Ph.D. in Education from Walden University – Completed August 2014.

Master of Arts in Education from the University of Phoenix – Completed December 2004.

Bachelors of Science in Business & Management (BSBAM) from the University of Redlands – Completed March 2002.

Certification

Previously earned an Arizona Secondary Teaching Credential in Business.

Current Research

My doctoral dissertation is an exploration of the historical relationship of faith and science, which includes an analysis of the attitudes and beliefs concerning nature and its exploration within historically prominent world cultures; how particular faith traditions shaped various civilizations' cosmologies; and the principal historical figures and events in the progression toward genuine science.

Teaching Experience

Adjunct Instructor – Religious Studies at Regis University (March 2014 to Present)

Adjunct Instructor – College of Education University of Idaho (January 2007 to November 2009)

Special Education Instructional Assistant – St. Maries Joint School District #41 (September 2002 to May 2006)

Assistant Football Coach – University of La Verne (1998 - 2001)

Assistant Football Coach – The Claremont Colleges (1997)

Assistant Football Coach – University of La Verne (1991 – 1996)

Courses Taught

World Religious Traditions

Foundations of Education

General Education Development (GED) Preparation:

- Language Arts, Reading & Grammar
- Applied Mathematics
- Mathematics Computation
- Social Science
- Science

English as a Second Language (ESL)

Small Business Development

Professional Business Experience

Purchasing Manager – Montana State University (May 2006 – July 2006)

Project Manager – KPRS Construction Services, Inc. (August 2001 – August 2002)

Project Manager - Andrew L. Youngquist Construction Services, Inc. (February 2000 – July 2001)

Project Manager - Austin/Jones Corporation, Inc. (October 1997 – July 1999)

Project Manager - M&S Construction Management, Inc. (March 1995 – October 1997)

Project Manager – J.D. McKee Construction, Inc. (January 1992 – February 1995)

Project Manager – Thorpe Construction, Inc. (January 1990 – December 1991)

Project Manager – Birtcher Construction, Limited (January 1986 – December 1989)

Assistant Project Manager promoted to Project Manager – Stacon Corporation (November 1981 – December 1985)

Related Proficiencies

I am skilled in the use of various computer programs and software, including Microsoft Office, data management programs, project management programs, and Internet research strategies. My years of experience in business management, teaching, and coaching college student-athletes have developed my interpersonal skills and enhanced my desire to work with people of varying cultures, interests, and abilities.