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Conflicts between Science and Christian Theology: Historical Perspectives

Karissa D. Carlson
Northwestern College - Orange City, kcarlson@nwciowa.edu

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Department of Chemistry, Northwestern College

Introduction

Evolution: it's the word that inevitably creeps up in conversations regarding science and religion. Some Christians either fear the topic or avoid it altogether. Simply mentioning the term in a class can elicit a variety of responses from tension to anger to fear. The world around them only serves to reaffirm reactions, as vocal and widely publicized opponents of religious beliefs, such as the evolutionary biologist Richard Dawkins, make claims that supernatural belief is a delusion and evolution eliminates the need for a god. These viewpoints are used as evidence that science and religion are directly in conflict with each other and cannot find resolution. The conflict has even escalated to the status of warfare: some Christians perceive evolution as an atheistic enemy whose goal is to provide explanations that eliminate God. Their opponents view religion as anti-intellectual and an inhibition to the progress of science. This warfare mentality is further exacerbated by media coverage of the most verbal opponents on both sides of the debate. While there are moderate voices who are making their voices heard, evolution continues to be a highly polarizing subject among Christians and scientists.

This isn't the first time science and religion have encountered temporary tensions: through the centuries, a number of "conflicts" have arisen. In the 19th century, two classic publications by John William Draper[1] and Andrew Dickson White[2] claimed that science and religion have *always* been in conflict and future conflict is inevitable. In fact, there are historical situations that, at face value, appear to support Draper and White's thesis: Christians rejected the notion of atoms, limiting the progression of atomic theory, scientists once thought that molecules in living systems were infused with a 'vital force' that made something alive until Friedrich Wöhler provided evidence against that theory, Galileo's telescope provided evidence for a Copernican universe, which contradicted the Christian view of the universe. This historical perspective *appears* to validate the notion that the current conflict between evolution and Christianity will not be resolved and that future clashes between these two disciplines are inescapable.

This conflict rhetoric makes for an interesting dynamic in the personal lives of scientists who are dedicated to their faith, yet committed to studying the sciences. If scientists choose to accept evolution as a comprehensive description of biology, geology, and a host of other disciplines are they denying their faith? If they choose to reject evolution in light of their belief system, are they denying science? Is there an inherent distrust of science that underlies much of what they are learning? Or, can they honestly seek truth in science and in their faith? These are the types of issues that I have wrestled with,

[1] Draper, John William. History of the Conflict between Religion and Science, London, 1874.
[2] White, Andrew Dickson. A History of the Warfare of Science with Theology in Christendom, 1896.

and contrary to the predominating view that history validates Draper and White's thesis, I've found that a historical perspective offers valuable insight into the dynamic relationship between these two important components of my own life and has provided potential avenues for resolution between them.

It is true that, science and religion in the Western world have been closely connected throughout history; changes in one discipline have influenced the other. However, the argument has been made by several historians that many of the historical "conflicts" have not been true conflicts between science and religion and many of these situations are better categorized as conflicts between scientists or between religious leaders, or a situation that is better understood in the context of the time period in which it existed[3,4,5,6]. In addition, many of those historical tensions seem to be non-issues in our current state of understanding; they were resolved somewhere along the way. An examination of these historical tensions offers insight to resolving current struggles and preventing future issues between religion and science.

In this paper, I will specifically examine the historical development of Dalton's atomic theory which was originally rejected by Christians. Through the examination of this currently non-explosive topic, I intend to highlight the means by which science and religion interactions have led either to conflict or resolution. Based on this historical perspective, I will propose that the predominating scientific views, or paradigms, of each time period have been highly influential on theological paradigms of the same time periods. I will make the claim that the scientific paradigm of atheistic evolution and the theological paradigm of biblical literalism are not likely to find resolution without a change in one or both paradigms. Furthermore, I propose that, if Christianity is to avoid future conflicts with natural explanations, Christian theology should adopt the model of Dialogue with science. A redefinition of natural theology offers the avenue by which this type of interaction may be established.

Historical Relationships between the Christian Church and Atomism

Dalton's atomic theory, developed in the 19th century by the English chemist John Dalton, is a foundational concept in chemistry. An introductory General Chemistry textbook describes Dalton's Atomic Theory according to the following statements:

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[3] Shea, William R. Recent Themes in The History of Science and Religion, part 1, ed. Donald A. Yerxa, University of South Carolina Press, Columbia 2009.

[4] Lindberg, David C. "The fate of science in patristic and Medieval Christendom", The Cambridge Companion to Science and Religion, ed. Peter Harrison, Cambridge University Press, 2010.

[5] Russell, Colin A. "The Conflict of Science and Religion", Science and Religion, A Historical Introduction, ed. Gary B. Ferngren, The Johns Hopkins University Press, 2002.

[6] Lindberg, David and Numbers, Ronald. "Beyond War and Peace: A Reappraisal of the Encounter between Christianity and Science", *Perspectives on Science and Christian Faith*, 39.3: 140-149.

1. Elements are made up of tiny particles called atoms.
2. Each element is characterized by the mass of its atoms.
3. The chemical combination of elements to make different chemical compounds occurs when atoms join in small whole-number ratios.
4. Chemical reactions only rearrange how atoms are combined in chemical compounds; the atoms themselves don't change[7].

For any current student in chemistry, these basic tenets of the discipline are not surprising or in any way controversial[8]. It would seem absurd for an individual to argue that the concept of atoms is, in any way, contrary to religious beliefs, given our modern understanding of science and religion. In the early Christian church, however, atomism was rejected because it was believed to be an atheistic philosophy.

In order to understand this tense relationship between religion and science, this paper will examine the historical, religious, and social factors that led to the formulation of the Atomic Theory. To accomplish this, I will begin by defining key terms and relationships that will be used in this narrative. Then, the historical recounting of this story will begin in ancient Greece with two competing philosophies: Aristotelianism and Atomism. From there, I will describe how these philosophies were rejected or altered to result in Dalton's Atomic Theory. In light of this narrative, historical and current paradigms in science and Christian theology will be inspected to offer a model of interaction between these disciplines that might prevent future conflicts.

Defining 'science' and 'religion'

Before examining historical relationships between science and religion, it is important to recognize that 'science' and 'religion' in history do not necessarily resemble modern science and contemporary religions. In some historical contexts, science and religion were both encompassed by the same field of study: philosophy. It was not until after the Protestant Reformation and Scientific Revolution that they emerged as independent fields of study. The term religion first appeared in the 17th century and the terms 'science' and 'scientist' are not found in common use until the 19th century[9,10]. Thus, natural philosophy is the most accurate description of natural science throughout

[7] McMurry, Fay Chemistry, *6th ed*; Prentice Hall 2012

[8] With the recognition that the atomic theory, as stated, was a foundational theory that has required some minor modifications from our current level of understanding.

[9] Harrison, Peter. ""Science" and "Religion": Constructing the Boundaries", *The Journal of Religion*, 86: 81-106, 2006.

[10] Wilson, David B. "The Historiography of Science and Religion", Science and Religion, ed. Gary B. Ferngren, The Johns Hopkins University Press, 2002.

history. In the context of this paper, references to religion can be assumed to describe Christianity, as much of Western culture, in which modern natural science developed, was influenced by Christianity[11].

Historical accounts of relationships between science and religion are not easily categorized into clear modes of interaction, due to the complexities and intricacies of each situation[12]. John Hedley Brooke has defined six ways in which religion has historically influenced natural philosophy, particularly in the context of the Scientific Revolution[13]:

1. *Presuppositions*. The conceptions of natural philosophy that many held have been informed by religious beliefs; the understanding of nature was underwritten with the presupposition of a creator.
2. *Sanctions.* Religious beliefs have been employed as justification for natural philosophy and experimental science.
3. *Motivations.* Religious beliefs have provided motives for scientific inquiry, often as a means to prove the existence of God or to verify a religious event (such as a miracle).
4. *Regulation of scientific methodology*. Religious beliefs have provided the underpinning for specific methods of investigation, such as voluntarism.
5. *Criteria for choosing between competing theories.* When selecting between two scientific theories, religious beliefs have played a role in deciding which theory is preferred.
6. *Constitutive role in the content of scientific theories.* Religious beliefs have fulfilled the role of explaining natural phenomena that subsequently could be explained without theological reference.

As I follow the historical progress of the atomic theory from its philosophical inception to its experimental validation and formal statement by Dalton, I will highlight the first five influential factors described by Brooke. The sixth influence of Christianity as a *constitutive role in the content of scientific theories* will come into consideration later, when current relationships between science and religion are considered. The key individuals in this narrative and their role in the development of the atomic theory are summarized in Table 1.

Ancient Aristotelianism

Aristotle (384-322 BC) wrote philosophical treatises that addressed nearly every aspect of life, including rhetoric, politics, biology, psychology, economics, natural philosophy, and metaphysics. His philosophy had an immense impact on Greek civilization and was even more influential in western civilization from the 13th to the 17th century. No figure in history has shaped our understanding of

[11] There are many interesting developments between science and other religions but, given my own Christian beliefs, I will focus on relationships between Christianity and science.

[12] Cantor, Geoffrey, and Kenny, Chris, "Barbour's Fourfold Way: Problems with His Taxonomy of Science-Religion Relationships", 2001, *Zygon,* 36(4): 765-781.

[13] Brooke, John Hedley, Science and Religion Some Historical Perspectives, 1991, Cambridge University Press; 19-33

natural philosophy as significantly as Aristotle[14]. His philosophy of nature also played a significant role in discouraging the Christian church from embracing the notion of atoms.

Aristotle's natural philosophy was primarily concerned with the investigation of nature to provide teleological accounts for events that occurred in nature[15]. To accomplish this, he relied heavily upon observation and rational thought, without emphasis on empirical data. Through such observations, he distinguished four causes: material, formal, efficient, and final. The material cause for an item was one of the four earthly elements he identified: earth, air, fire, and water. Each element had an earthly location that it would tend to move towards, causing the event (Fire moved towards celestial bodies and water moved toward earth, causing fire to rise and rain to fall). The formal cause was the constitution, or shape, of the item and efficient causes explained how something was accomplished. The final cause explained why something occurred. For example, the final cause for a person going on a walk was gaining health from the walk.

Physical changes in nature, according to Aristotle, were the result of introduction or removal of chemical qualities (hot, cold, wet, and dry) to or from a substance. The earthly elements were composed of a combination of these qualities. Water was cold and wet, earth was cold and dry, air was hot and wet, and fire was hot and dry. Introduction of a new quality resulted in the physical changes observed in nature[15].

According to Aristotle there were three different 'sciences': natural philosophy, mathematics, and the 'divine truth' metaphysics (theology) [16]. Natural philosophy and mathematics were the lower sciences and they served the purpose of establishing truth, which ultimately led to metaphysics. With respect to metaphysics, Aristotle conceived God to be an eternally existing being; God was not the creator of the world, since Aristotle could find no causal explanation for the presence of a creator who creates. This would require that there exist another being that created that creator, and so on, repeating without end. Without a creator, Aristotle reasoned that the elements were eternal. God served to unify the world and keep it functioning as the final cause of everything that comes about. Aristotle's God was the Unmoved Mover of the cosmos and everything within it, but he was unaware of this fact[14].

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[14] Grant, Edward. "Aristotle and Aristotelianism", Science and Religion, Ed. Gary B. Ferngren, The Johns Hopkins University Press, 2002.

[15] Hankinson, R.J. Cause and Explanation in Ancient Greek Thought, Clarenden Press, Oxford, 1998

[16] Cooper, John M. "Aristotle." The Cambridge Companion to Greek and Roman Philosophy. Ed. David Sedley. Cambridge University Press, 2003.Cambridge Collections Online. Cambridge University Press. 23 July 2012 DOI:10.1017/CCOL0521772850.006

Ancient Atomism

The ancient philosophical development of atomism is not as clearly defined as Aristotelianism, since many of the original atomistic works were not preserved in ancient Greece. In fact, one of the primary sources of information regarding atomism is Aristotle's writings, in which he refers to the Atomists Leucippus and Democritus[17]. Leucippus is often recognized as the originator of the theory of atomism [18], although Democritus, his student, is more widely celebrated as the one who truly developed and established atomism. According to the Atomists, the natural world was composed of two different constituents: individual physical bodies and void[19]. The individual bodies, called atoms, were considered the primary items that created all else through formation and dissolution of aggregates of atoms[17]. Atoms were separated by nothing, the empty space referred to as 'void'.

Following Democritus and Leucippus, Epicurus (341-270 BCE) elaborated on the atomist hypothesis. He integrated it into his Epicurean physics[20] as set out below:

1. Nothing comes from what is not nor disappears in what is not.
2. The all is made of bodies and void, which are the only complete natures.
3. Amongst bodies, some are composites; others are those from which composites are made.
4. The all is unlimited or infinite both in the number of atoms and the extent of void.
5. The number of different atomic shapes cannot be conceived.
6. The atoms move constantly and endlessly because of the existence of void.

With these principles as his philosophical framework, Epicurus developed a very materialistic view that rejected teleological explanations: if all things are composed of atoms, then all of life is the result of atoms interacting without any purpose, direction, or final cause[15,21]. He reasoned then, that the highest pursuit in life should be the pursuit of pleasure. It is important to note that, with his using the term 'pleasure', Epicurus meant diminution of pain was the highest pursuit, not the lascivious, self-indulgent philosophy often associated with Epicureanism[21]. While Epicurus did not deny the existence of gods or discourage religion, he reasoned the gods were too busy pursuing their own pleasures to be

[17] Taylor, C.W. "The atomists." The Cambridge Companion to Early Greek Philosophy. Ed. A. A. Long. Cambridge University Press, 1999. Cambridge Collections Online. Cambridge University Press. 23 July 2012 DOI: 10.1017/CCOL0521441226.009

[18] Berryman, Sylvia, "Leucippus", The Stanford Encylopedia of Philosophy, Ed. Edward N. Zalta, 2010.

[19] Berryman, Sylvia, "Ancient Atomism", The Stanford Encyclopedia of Philosophy, Ed. Edward N. Zalta, Winter 2011.

[20] Morel, Pierre-Marie. "Epicurean atomism." The Cambridge Companion to Epicureanism. Ed. James Warren. Cambridge University Press 2009. Cambridge Collections Online. Cambridge University press. 23 July 2012 DOI: 10.1017/CCOL9780521873475.005.

[21] Greenblatt, Stephen. The Swerve: How the World Became Modern. W.W. Norton & Company, 2011.

concerned with humans. Social factors, described below, led to the association of Epicureanism with atheism.

Early Christianity and Nature

Members of the early Christian church had the difficult task of assimilating Christian doctrine into a coherent framework within the Greco-Roman world in which Scholastic philosophies, such as Aristotelianism and Epicureanism, were dominant. Many of the early Christians were products of Greco-Roman schooling and, although they rejected some metaphysical assumptions of Scholastic philosophies, many of the underlying philosophical methodologies were incorporated into Christianity.

Origen (185-254 CE), the Alexandrian father of the church, was inspired by scriptural references to creation which implied that nature was a book that could be 'read' by humans:

> I think that He who made all things in wisdom so created all the species of visible things upon the earth, that He placed in some of them some teaching and knowledge of things invisible and heavenly, whereby the human mind might mount to spiritual understanding and seek the grounds of things in heaven[22].

According to Origen, both the Bible and nature, when read properly, were infused with symbols that could provide spiritual insight, as both were mean to be interpreted not only literally, but also allegorically[23]. Allegorical reading of the Biblical narratives provided several layers of understanding that were relevant to past events as well as ones to come in the future. Peter Harrison has described how allegorization led to studying nature for the purpose of discovering underlying spiritual lessons and imbued beasts and birds with symbolism and spiritual importance in the process[24]. A collection of medieval books called the 'bestiaries' recorded many of these important allegories. Some of the animals described in the bestiaries, such as the pelican, were real and others, like the unicorn, were not known to exist. The allegorical symbolisms described in the bestiaries were also not always accurate descriptions of natural phenomenon. For example, the pelican was described to kill its own young, then cut open its own side three days later and bleed upon its young, raising them back to life. The obvious allegorical lesson here pertains to Christ's death and resurrection. The spiritual lessons were the important components of such allegorizations, while the accuracy of these articles was not a concern. In the very early church, then, natural philosophy was studied through the bestiaries primarily for the spiritual insights it offered, rather than to obtain truthful natural descriptions.

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[22] Lawson, R.P., Origen The Song of Songs, Commentary and Homilies, Longmans Green and Co., 1957.
[23] Harrison, Peter. "The Bible and the Emergence of Modern Science" *Science and Christian Belief*, 2006, 18: 115-132.
[24] Harrison, Peter. The Fall of Man and the Foundations of Science, Cambridge University Press, 2007.

St. Augustine, bishop of Hippo in North Africa, is recognized as the primary theologian that established early Christian attitudes towards nature[25]. Augustine was hesitant to attribute much value to pagan philosophies, such as Aristotelianism, but he was influenced by Origen's allegorical reading of both scripture and nature. He recognized that natural philosophy was a means to an end, so he encouraged studying natural philosophy solely for the purpose of biblical exegesis. Thus, natural philosophy was relegated to the status of handmaiden to theology and it was actively pursued as a religious necessity[26]. Augustine's *handmaiden formula* dominated the Christian pursuit of natural science in the early middle ages and a handful of educated Christians wrote treatises entwining natural philosophy within Christianity.

Returning to Brooke's defined influences of religion on natural philosophy, Augustine played a significant role in providing *motivation* for the study of natural philosophy. While Augustine did not see any external value in natural philosophy itself, he did value examining natural phenomena as a spiritual practice for understanding Scripture. The study of nature, therefore, was motivated by the spiritual growth one would gain from the exercise.

Christianizing Aristotle

Christian attitudes towards natural philosophy shifted around the 11th and 12th centuries of the later Middle Ages. Europe experienced renewal that led to many changes, including social, economic, and political growth. With this growth came a resurgence of Scholasticism which increased interest in Greek philosophy. Due to its encompassing of nearly all aspects of life, Aristotelian philosophy was deeply integrated into the curriculum of the educational system[27]. This presented a challenge to Christian theology, as components of Aristotle's philosophy were potentially incompatible with Christian doctrine. For example, recall that Aristotle claimed the earth was coeternal with God; the world was not created by God. Furthermore, Aristotelianism was exclusively dependent upon sense perception and rationalism to achieve truth, excluding spiritual or biblical revelation.

Aristotle's philosophy was too socially valuable to eliminate, though. Thomas Aquinas (1225-1274), Christian theologian and philosopher, was a key figure in the process of accommodating Aristotle in Christianity[27]. Aquinas, in his work *Summa Theologiae*, worked to make Aristotle's philosophy fit into the existing Christian theology. To accommodate the Aristotelian eternal earth, Aquinas argued that

[25] Lindberg, David C. "Early Christian Attitudes toward Nature", Science & Religion A Historical Introduction, Ed. Gary B. Ferngren, The Johns Hopkins University Press, 2002.
[26] Gauch, Hugh G., Jr. Scientific Method in Practice, Cambridge University Press, 2003.
[27] Lindberg, David C. "Medieval Science and Religion", Science & Religion A Historical Introduction, Ed. Gary B. Ferngren, The Johns Hopkins University Press, 2002.

there was no reason why the earth couldn't be both created and eternal. This was, apparently, an acceptable accommodation. As time progressed, Christian theology became deeply embedded in Aristotelian philosophy.

Christian Rejection of Atomism

In the 2nd and 3rd centuries, while Augustine was promoting natural philosophy as handmaiden to theology, Epicurean philosophy came to be perceived as a threat to Christianity. Not only, had the Epicureans rejected teleological explanations, the Christian concepts of Incarnation and resurrection of the body were incompatible with the notion of atomism. Early Christian authors, such as Tertullian and Lactantius, openly attacked Epicureanism and presented Epicurus and his followers as madmen with hedonistic lifestyles. Epicurus's pursuits of pleasure, as well as his inclusion of women in his school, were likely the sources of these inflated claims by the Christians[21]. By the 4th century, Epicureanism was definitively categorized as a pagan, atheistic religion and primarily rejected among Christians.

With the integration of Aristotelianism into Christianity in the late medieval period, Epicureanism was dealt a final blow. Aristotle claimed all matter was composed of the four visible elements that were continuous; Epicurus's atoms were indivisible, invisible, and separated by void. Aristotle believed in the immortality of the soul; Epicurus believed that atoms constituted all of humanity. Thus, Epicurean natural philosophy was not compatible with the Aristotelian conception of the world and, by association it was not compatible with Christianity. Epicurean philosophy was prohibited by the church and atomism was rejected along with it. Eventually, the works and philosophy of Epicurus and his followers decreased in circulation and most were destroyed, degraded, or lost in monastic libraries.

Now you can see an example of Brooke's category of Christianity influencing science as the *criteria for selecting between competing theories*. The philosophies of both Aristotle and Epicurus were viable theories concerning natural philosophy during the Scholastic period. Aquinas and church leaders in the Scholastic period employed Christianity to establish Aristotelian philosophy as the philosophical foundation of Christian theology. Epicurean philosophy was nearly forgotten as a result of that religious decision.

Reviving Atomism

Throughout the medieval period, the Christian church in the western world was the source of authority and knowledge—both spiritual and natural. Aristotle continued to dominate the western educational system and Christian theology until the 16th century when the Protestant Reformation

changed the religious and academic climate. By questioning the authority of the Catholic Church, the reformers brought into question the source of all authority. With the protestant emphasis on Scripture for salvation, rather than the church, came an emphasis on individual reasoning, rather than reliance on the established authority. Aristotelian philosophy was wounded deeply when Galileo claimed evidential support for the Copernican model of the universe (the earth revolving around the sun) rather than the Aristotelian model (the sun revolving around the earth). It became necessary to look for sources of truth outside of the church and beyond Aristotle. Ancient texts were revisited and revised. In short, the Reformation upset both the theological and philosophical foundations of the time.

Laurence Carlin argues that these changes had an immense impact on the development of natural philosophy and, in particular, on the appearance of Empiricists in Europe[28]. The Empiricists were philosophers who rejected the final causes of Aristotelianism and focused on questions of what knowledge *is* and *how* one knows when one has knowledge. Empiricists emphasized the acquisition of empirical data through experimentation rather than the Aristotelian example of observation and reason. Empirical science instituted an altogether different mode of investigation—the 'new science'. Carlin lists eight natural philosophers whom he considers the most influential Empiricists; two of these Empiricists are crucial to this narrative: Pierre Gassendi (1592-1655) and Robert Boyle (1627-1691). These natural philosophers significantly contributed to reviving the Epicurean notion of atoms and revising the philosophy to fit into the changing worldview of their time.

Pierre Gassendi was a priest who became dissatisfied with Aristotelianism and the educational requirement to teach the philosophy as part of the institutional curriculum. This motivated Gassendi to 'Christianize' atomism; that is, to prove that Epicurean atomism, with a few modifications, was better suited to Christianity than Aristotelianism[29]. Gassendi argued that God created a finite number of atoms at the beginning of the universe, rather than the Epicurus's infinite number of atoms. In rejection of Epicurean materialism, Gassendi also claimed that humans had an immaterial soul that causally influenced the material body. With these modifications, Gassendi eliminated the primary theological arguments against Epicurean atomism and wove it into a framework that was coherent with post-Reformation theology. Although Aristotelianism and Epicureanism were not necessarily equally competing philosophies, I propose that this is another situation where Christianity was used as the *criteria for selecting one theory over another*, as defined by Brooke. In a reversal of the work of 3rd century philosophers, Gassendi used Christianity to select Epicurean atomism over Aristotelianism.

[28] Carlin, Laurence. The Empiricists, Continuum International Publishing, 2009.
[29] Osler, Margaret J. "Gassendi on Fortune, Fate, and Divination", Atoms, *Pneuma*, and Tranquility: Epicurean and Stoic Themes in European Thought, ed, Margaret J. Osler, Cambridge University Press, 1991

Carlin describes Robert Boyle as a deeply religious man dedicated to the triumph of the Empiricism over Aristotelianism. Boyle worked towards this goal by developing a philosophy that supported Christianity; a large number of his published works were theological in nature, adjudicating the mechanical philosophy of the 'new science' with Christianity[30]. Committed to reconciling atomism with Christianity, he put considerable effort into eliminating the atheistic reputation that was associated with Epicureanism. William R. Newman, in his book Atoms and Alchemy, describes the process by which Boyle established this new 'chemistry' into a philosophy called corpuscularianism[31]. Newman claims that Boyle heavily relied on Gassendi's philosophy, but also incorporated experimental work by Daniel Sennert, an alchemist. In his corpuscular hypothesis, Boyle claimed that all bodies are made up of one kind of material substance that was contained in minute particles called corpuscles, which were similar to Epicurean atoms. Boyle's corpuscles, however, were theoretically divisible and capable of alchemical transmutations, while Epicurean atoms were not. Despite his preoccupation with alchemy, Boyle's corpuscular hypothesis set a strong theoretical foundation for the development of modern atomism.

At this point, we can see several of Brooke's influences of Christianity upon the development of modern natural philosophy. In the process of establishing natural philosophy as an empirical field of study, both Gassendi and Boyle operated with the *presupposition* of God as creator, since their religious views were implicit in the natural explanations they employed. Religious beliefs also *sanctioned* the investigation of nature for Boyle. Common to the 16th and 17th centuries was the notion that God had provided revelation through two books: the book of Scripture and the book of nature[32]. Boyle took this concept so far as to argue that the natural philosopher was equivalent to a Christian priest[33]. Natural philosophy, therefore, was not only necessary, but essential. As the study of Scripture was an obligation of the faith, so, too, was the study of nature. As a result, Boyle justified the expanding empirical study of nature, including his corpuscular hypothesis, as an obligation of the faith.

Christianity was also Boyle's *motivation* to study nature. Upon his death, he left an endowment to Oxford University to establish a series of lectures and presentations – eventually known as the Boyle

[30] MacIntosh, J.J. "Boyle on Epicurean atheism and atomism", Atoms, *Pneuma*, and Tranquility: Epicurean and Stoic Themes in European Thought, ed, Margaret J. Osler, Cambridge University Press, 1991

[31] Newman, William R. Atoms and Alchemy: Chymistry and the Experimental Origins of the Scientific Revolution, the University of Chicago Press, 2006.

[32] Harrison, Peter. " 'The Book of Nature' and Early Modern Science", The Book of Nature in Early Modern and Modern History, eds. Van Berkal and Vanderjagt, Leuven: Peeters, 2006.

[33] Shapin, Steven. A Social History of Truth: Civility and Science in Seventeenth-Century England, The Unviersity of Chicago Press, 1994.

Lectures - dedicated to employing science as a means to prove the validity of Christianity[34]. Boyle's goal was to present scientific evidence that supported Christian faith and discouraged atheism. Thus, we can see how Boyle's religious motivations contributed to the establishment of natural philosophy as an empirical, scientific field.

Finally, both Gassendi and Boyle adhered to voluntarism, which provided a means of *regulation of scientific methodology*. Voluntarism is the notion that, by his own free will, God chose to create the world with order that can be observed by humans[35]. By employing empirical methods, one could test and discern how God created[36]. As voluntarists, Gassendi and Boyle selected empirical methodologies as the means by which to study nature so they might gain insight into God's creation.

The work of Gassendi, Boyle, and several other natural philosophers began to accumulate empirical evidence and philosophical support that eventually led to the work of John Dalton in the 19th century. Dalton compiled his own experimental work, empirical results from the work of Antoine Lavoisier and Joseph Proust in the 18th century, the philosophical work of Gassendi and Boyle, and influence from Newtonian physics into an atomistic theory of nature[37]. What he produced is Dalton's atomic theory. This theory has provided the foundation upon which much of modern chemistry is based. Up until the 19th century, religious considerations continued to be employed in order to lend credence to the 'new science' of empiricism[38]. Yet, for Dalton in the 19th century, science was just emerging as a discipline of study that was fully extricated from philosophy and theology[39]. Despite the fact that he was a deeply religious Quaker, it is not clear whether or not Dalton's religious perspectives influenced or motivated his work as a chemist.

Alan Chalmers has made the case that much of Dalton's atomic theory was more philosophical than empirical in substance[37]. As a result, subsequent experimentation by several other chemists was required in order to fully substantiate the claim. The discoveries of subatomic particles, isotopes, and nuclear reactions have subsequently resulted in modern atomism. Dalton's atomic theory has required revisions in order to arrive at our current understanding of atomism—a modified version of the original

[34] Dahm, John J. "Science and Apologetics in the Early Boyle Lectures", Church History, Cambridge University Press, 1970.
[35] Henry, John. "Religion and the Scientific Revolution", The Cambridge Companion to Science and Religion, ed. Peter Harrison, Cambridge University Press, 2010.
[36] Harrison, Peter. "Voluntarism and Early Modern Science", *History of Science*, 2002, 40: 63-89.
[37] Chalmers, Alan. The Scientist's Atom and the Philosopher's Stone, Boston Studies in the Philosophy of Science, 2009.
[38] Harrison, Peter. "Religion, the Royal Society, and the Rise of Science", *Theology and Science*, 2008, 6(3): 255-271
[39] Brooke, John Hedley. "Science and Secularization", The Cambridge Companion to Science and Religion, ed. Peter Harrison, Cambridge University Press, 2010.

theory. Along this same time course, the relationship between science and religion has also been modified. Modern science has been desacralized from the religiously motivated science of Boyle and Gassendi. Science is understood to embody a methodology that is opposite from that of religion: science is seen as objective and open-minded; religion is seen as subjective and closed-minded. Science is expected to be an independent discipline, fully extracted from those historical influences of religion described by John Brooke.

Scientific and Theological Paradigms in History

Conflicts, such as those surrounding evolution, still exist, indicating interactions between science and religion still exist. What, then, can we understand about modern relationships between these disciplines in light of this historical narrative? It's clear that the relationships are now very different from the historical ones described above. I propose that all interactions between science and religion, whether modern or ancient, are best understood in the context of the existing frameworks, or paradigms, of science and theology in the time period in which the interaction occurred.

Scientific paradigms

While studying the history of science, Thomas Kuhn (1922-1996) observed that there were distinct scientific traditions in history that were later replaced by newer, very different, traditions. These paradigms[40], as Kuhn dubbed the 'scientific traditions', were composed of a set of methodological and conceptual assumptions that determined what types of questions constituted legitimate scientific inquiry. Kuhn described a paradigm as being similar to "normal science"[41]. That is, a typical scientist will be trained in a research tradition that is modeled after historical examples that led to the establishment of that tradition. Inherent in the tradition are the metaphysical assumptions of what types of bodies exist in nature. While "normal science" can acquire a great deal of information and make significant progress in its paradigm, Kuhn argued that there are also periods of philosophical change that happen suddenly, rather than progressively, resulting in new scientific concepts and new methodologies. He introduced the term 'paradigm shift' to describe these scientific revolutions.

Kuhn argued that scientific data and observational language is dependent upon the paradigm in which it was developed and is incommensurable with data from other paradigms. In other words, what is considered essential in one paradigm is a construct of the existing paradigm; following a paradigm shift that previously essential component may be inconsequential in the new paradigm. Kuhn reasoned

[40] Kuhn, Thomas S. The Structure of Scientific Revolutions, The University of Chicago Press, 1962.
[41] Kuhn, Thomas S. The Structure of Scientific Revolutions,2nd ed, The University of Chicago Press, 1970.

that language between paradigms was also incommensurable[42]: the term 'element' was defined very differently by chemists in the 18th century than it is in modern chemistry. To elaborate on this example, recall that Aristotle's 'element' was earth, air, wind, or fire. To use the term 'element' in this manner in modern chemistry would be unproductive, as modern chemistry is not understood within the Aristotelian paradigm.

Kuhn also proposed that an existing paradigm is resistant to falsification; that is, it is difficult to initiate a scientific revolution. If data is observed to be inconsistent with a paradigm, it is either accounted for by *ad hoc* hypotheses or minor modifications to the existing paradigm. A paradigm will be overthrown only when an overwhelming amount of data has accumulated and a scientific crisis is encountered.

When encountering a scientific crisis, the choice to adhere to one particular paradigm over another cannot be predicted or decided by rules. Rather, it is based upon personal judgment. Kuhn argued that adherence to a paradigm was not irrational, but logically described by the criteria typically employed by scientists. Two individuals might reach different conclusions due to the relative value for criteria that an individual holds.

Through his historical analysis of science, Kuhn took a presumably objective field of study and described its philosophy in subjective terms. Needless to say, Kuhn initiated a bit of a crisis with his own work: critics argued that science is not purely a social construction. In an attempt to retain the subjective, historically relevant aspects of Kuhn's *Structure*, while maintaining the objective and rational features of science, Ian Barbour has reformulated this concept of scientific paradigms in *Religion and Science*[43]:

1. "All data are paradigm-dependent, but there are data on which adherents of rival paradigms can agree.
2. Paradigms are resistant to falsification by data, but data does cumulatively affect the acceptability of a paradigm.
3. There are no rules for paradigm choice, but there are shared criteria for judgment in evaluating paradigms."

In these three statements, Barbour has addressed some of the primary critiques of Kuhn's theory, while maintaining the fundamental concept of prevailing scientific traditions that are distinctly different from other traditions throughout the course of history.

In the context of scientific paradigms, as described by Kuhn and Barbour, the progress and inhibition of movement towards Dalton's atomic theory can be explained. The key players in this story: Aquinas,

[42] Kuhn, Thomas S. The Road since Structure, The University of Chicago Press, 2000
[43] Barbour, Ian G., Religion and Science: Historical and Contemporary Issues, 1997, Harper Collins

Gassendi, Boyle, and Dalton lived in periods of very different scientific paradigms (Table 1). I propose that each of these individuals made their contributions to the development of the atomic theory as a result of the prevailing paradigm of their time.

Thomas Aquinas was trained in the Scholastic paradigm, which was primarily dominated by Aristotelianism. Recall that Aristotle categorized natural philosophy and metaphysics together as 'science'. Aquinas, therefore, could also be categorized as a natural philosopher and theologian. Within this paradigm, the natural world could only be understood through Aristotle's causal descriptions based upon observation and logical reasoning. Other philosophies, such as Epicureanism, were incommensurable with data within this paradigm. Despite the fact that there was religious 'data' that contradicted the Scholastic paradigm (the Christian doctrine of the soul, as well as the creation of the earth), minor modifications were made to account for those anomalies. Aquinas also adhered to the Aristotelian paradigm because it was all-encompassing not because of one piece of data that was particularly convincing to him.

Pierre Gassendi and Robert Boyle, in the 16th and 17th centuries, lived within the time frame of a paradigm shift: the Scientific Revolution. In effect, enough data was accumulating through the works of Kepler, Galileo, and Newton to throw serious suspicion on the geocentric model of the cosmos that had fit so well within the Scholastic paradigm. Galileo, with newly developed optics, provided physical evidence for the Copernican model, throwing the prevailing paradigm into question. An important byproduct of Galileo's work was the emergence of experimental investigation as a valid means to test a theory. Gassendi and Boyle both promoted this new mechanical approach and, within their own abilities, worked to provide evidence for the elimination of the Aristotelian approach to nature. In the process, they resuscitated Epicurus's philosophy and Boyle presented the first evidence for the existence of atoms.

Following the Scientific Revolution, the Newtonian paradigm placed a strong emphasis on experimentation to provide empirical evidence in support of scientific claims. Dalton, within this paradigm, was compelled to validate the atomic theory through his own experimental work and the work of other experimentalists.

The Paradigm of Evolution

In light of this these historical paradigms, it is worth considering the current scientific paradigm, or paradigms. Science is highly diversified into a variety of disciplines that are often distantly related with their own "normal science". Ian Barbour claims that there might be paradigms within highly specialized fields that are applicable to only a small number of experts. Such paradigms are not likely to

impact the everyday life of ordinary individuals or even the way in which scientists outside of that particular field understand the world.

On the other hand, there are paradigms, such as global warming or mathematical modeling, which describe the inherent viewpoint of several fields of science. Evolution is also one of these paradigms. The publication of Darwin's *On the Origin of Species,* in conjunction with the existing theory of natural selection posited by Jean-Baptiste Lamarck and William Paley[44], provided enough accumulated evidence to initiate a paradigm shift. Evolution provided a comprehensive means of understanding the history of the earth through the processes of natural selection and gradual change. Evolutionary theory has significantly impacted many fields of study in the natural sciences and other disciplines, such as history and sociology, and has become a dominant paradigm in these fields. Modern scientific data is understood in light of this paradigm of evolution and the theory motivates the types of questions that are asked today. For example, one motivation for many of the recent genome projects, including the Human Genome Project, was to provide genetic evidence for the evolutionary history of organisms. Genetic sequence comparisons provide evidence for the similarities and differences between organisms which, in light of the paradigm of evolution, are interpreted as evolutionary relationships and distinctions.

Similar to the context of any paradigm, if evidence is presented that does not fit with the current understanding of evolution, *ad hoc* hypotheses are developed to account for those anomalies. The paradigm is not rejected. Likewise, if evidence is not available to account for every component of the paradigm, it is assumed that we need further investigation in order to close those gaps in knowledge. The paradigm is not abandoned. Among most scientists it is understood that, as the state of the field is today, there is not enough accumulated reliable evidence to question the paradigm of evolution. If opponents of evolution question the validity of evolutionary theory, their arguments are primarily unfruitful among scientists, as it is not easy to understand science outside of the paradigm one is trained in.

[44] Moore, James. "Charles Darwin", Science & Religion A Historical Introduction, Ed. Gary B. Ferngren, The Johns Hopkins University Press, 2002.

The field of biochemistry, in which I was trained as a scientist, also functions within the paradigm of evolution. As described above, biochemists have determined sequences of genes and genomes of organisms, ranging from single-cellular organisms to humans. By aligning DNA sequences, it is evident that an immense number of genes are shared across organisms. For example, humans share a very large percentage of their DNA with many other organisms, indicating that they have many of the same genes. Genetic similarities are understood to indicate common origins and are used to construct phylogenetic trees, or trees of life, as shown in Figure 1. This figure is examining genetic relationships in the globin family of proteins[45], including hemoglobin the protein found in red blood cells which delivers oxygen through the bloodstream of vertebrates. This tree was constructed using DNA sequences encoding globin proteins from various organisms. Based upon genetic similarity, relationships can be determined between metazoan, human, and other globin proteins. As a product of the paradigm of evolution, it is typically understood that the branches in this tree represent

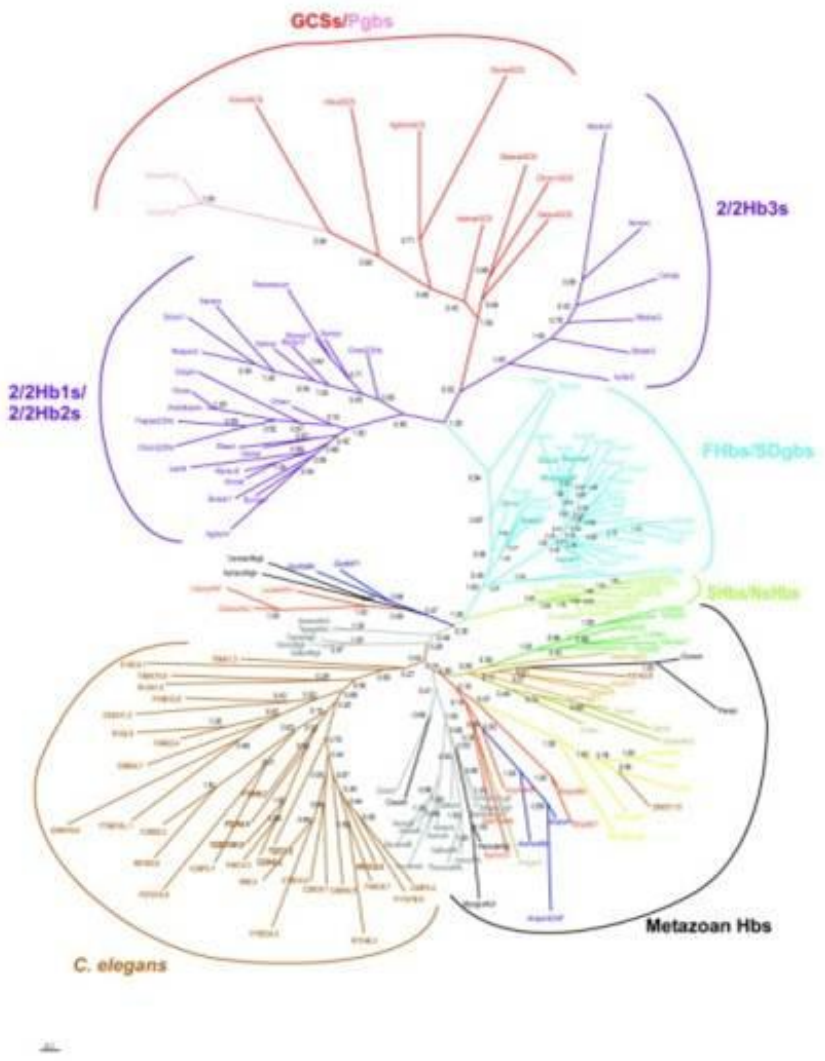

Figure 1. A Phylogenetic tree examining relationships between proteins in the globin family of proteins. This tree was constructed by examining genomic sequences encoding globin proteins across organisms in all three kingdoms of life. Branches in the three indicate variations in genetic sequence and are interpreted as evolutionary branches from a common ancestral organism. Figure obtained from Vinogradov, et a. BMC Evolutionary biology, 2006.

[45] Vinogradov, S.N., Hoogwijs, D. Bailly, X. Arredondo-Peter, R. Gough, J., Dewilde, S., Moens, L., Vanfletern, J. A Phylogenomic Profile of Globins. *BMC Evolutionary Biology*, 2006, 6, 31.

branches from early common ancestors. Thus, the evolutionary history of the globin proteins is inferred from this type of phylogenetic tree.

Furthermore, similarities in protein structure contribute data to understanding evolutionary relationships. The globin family of proteins, as described in Figure 1 above, is a great example of protein structure exhibited evolutionary relationships across organisms. Within this family are a variety of other oxygen carrying proteins that have the same protein structure, called a globin fold[46]. These proteins are not necessarily all composed of the same building blocks (amino acids), but when assembled into the entire protein, they are nearly identical in three-dimensional shape (Figure 2). This is an example of *divergent evolution* where a common ancestor, with a certain set of genes, gained slight modifications in its genome to evolve into a different organism while retaining most of the original DNA from the common ancestor. The similar structures of globin proteins are understood to indicate a common ancestor for all globin proteins. As the process of natural selection has occurred, the three-dimensional shape of the globins has been conserved, despite alterations in amino acid sequence and DNA sequences that encode the proteins.

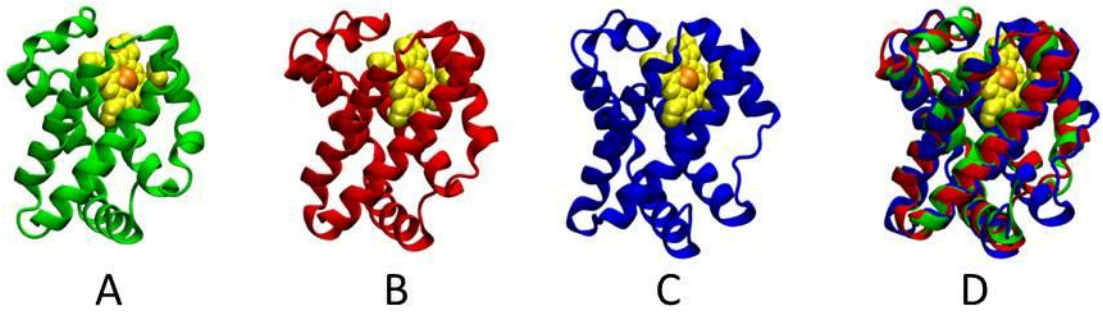

Figure 2. Structures of proteins from the globin family of proteins as an example of *divergent evolution*. A. Human hemoglobin, in red blood cells of human circulatory system (1HBB), **B.** Sperm whale myoglobin, in muscle (1MBD), **C.** Lupine leghemoglobin, in legumes (1GDJ), and **D.** Overlay of all three structures. The structural similarities of all three proteins are evident upon comparison of individual structure or by overlaying all three structures. There is a very large percent of similarity protein structure. This is an indication of *divergent evolution* in which these globin proteins evolved from a common ancestor composed of the same structural fold. Figures were rendered using VMD.

Protein structures also demonstrate *convergent evolution*, in which proteins not descended from a common ancestor have adapted similar structures. The serine protease enzymes are proteins that digest other proteins. These proteases are not similar in their overall three-dimensional shape, indicating that they did not evolve from a common ancestor. Rather, through the process of evolution, these enzymes converged upon a similar structural pattern in their active site: a catalytic triad

[46] Berg, Jeremy M., Tymoczko, John L., & Stryer, Lubert. "Exploring Evolution and Bioinformatics" Biochemistry W.H. Freeman and Company, 2006.

composed of three strategically placed amino acids that accomplish the chemical reaction involved with digestion of proteins (Figure 2). This catalytic triad is particularly advantageous for this type of reaction andwas, thus, accommodated into the structure of several enzymes that were not related by ancestry.

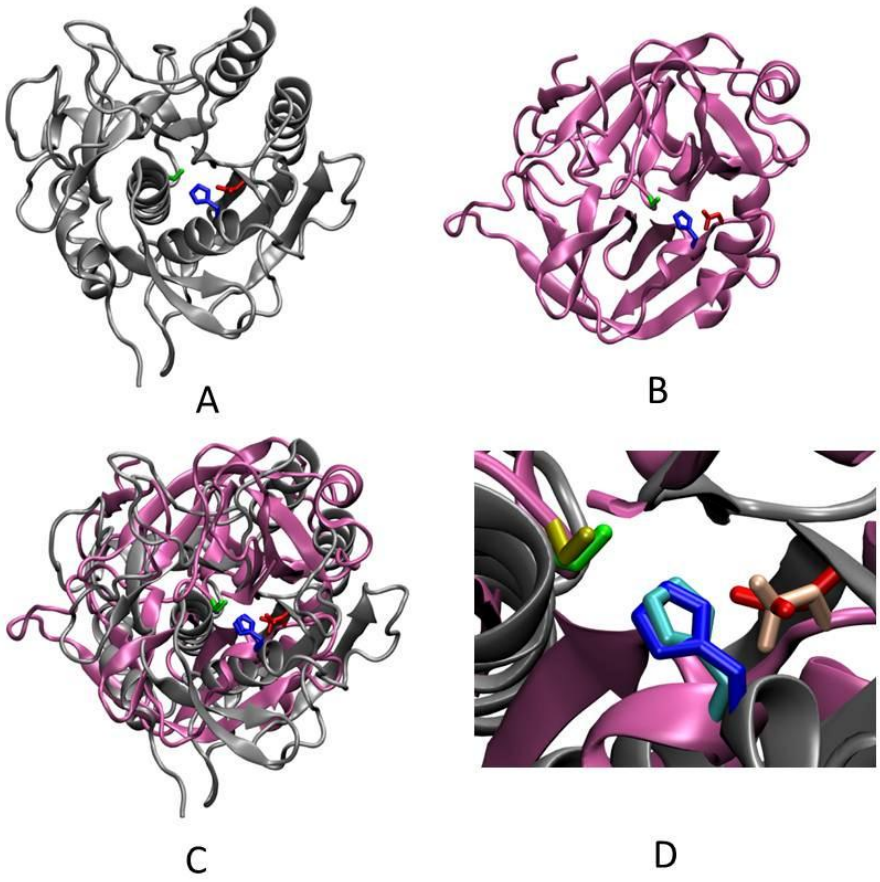

Figure 3. Structures of serine protease proteins as an example of *convergent evolution.* A. Chymotrypsin (1GCT), **B.** Subtilisin (1SUP), **C.** Overlay of chymotrypsin and subtilisin, and **D.** Zoomed in view of chymotrypsin-subtilisin overlay focusing on the catalytic triad of both enzymes. The overall structures of these two proteins are very different, as it is evident by the side-by-side comparisons of the structures (A and B) and the overlay of them (C), indicating that chymotrypsin and subtilisin do not have similar evolutionary origins. The catalytic triad, however, composed of three strategically placed amino acids (highlighted in D) is very similar between the two proteins, enabling these two very different proteins to catalyze the same type of reaction. This is indicative of an advantageous structural arrangement that was evolutionary adapted into two unrelated proteins.

Much of biochemistry has contributed to the elucidation of metabolic pathways, such as glycolysis, the Krebs cycle, DNA replication, and several others that describe how an organism utilizes energy sources to function. These pathways are complex and highly dependent upon the presence of a series of metabolites, enzymes, and cofactors for the pathway to properly function. Given the intricate dependencies of these pathways, Michael Behe has made the claim that biochemistry illustrates an

'irreducible complexity' that cannot be accounted for by evolution[47]. It is not currently possible to describe exactly how most biochemical pathways evolved, although there are many well-developed theories and ideas that have been proposed by well-respected scientists. Behe chooses to focus on the lack of scientific data, rather than acknowledging these well-founded ideas. He makes the argument that God fills in the existing gaps of knowledge by having created the world as we currently see it. This approach has been employed in the past and is an example of the sixth way in which Brooke claims religion has influenced science in history: *constitutive role in the content of scientific theory*. Through history, theology has filled in the gaps of knowledge by asserting God as the source of whatever information is lacking. This has played an important role for a given time period but, as evidence has accumulated, scientific descriptions have replaced the theological description. This is the danger in this type of approach: basing a theological principle upon a natural phenomenon that lacks a scientific description might eventually be explained by science. In the end, this could be more damaging, as the science might be understood to 'explain away' God.

Returning to Kuhn's descriptions, lack of evidence within a paradigm is not typically interpreted as evidence that contradicts the paradigm. For most scientists, evolution is too powerful a description of *all* nature to reject the paradigm based upon a deficiency of knowledge in a small subset of the paradigm. Rather, it is expected that, with further investigation, evidence will be found to close this gap. This particular absence of understanding regarding the origins of metabolic processes is already being investigated through a bottom-up approach as described by Juli Peretó in his recent tutorial review in *Chemical Society Reviews*[48]. This approach aims to recreate metabolic pathways from the simplest compounds to the most complex molecules in the conditions of primitive earth. There are various theories concerning the type and the timing of metabolic process that developed into life, but there is a general consensus that these steps are scientifically comprehensible. Furthermore, Peretó claims that it is accepted among scientists that experiments will eventually reproduce the step-wise processes of metabolism that originated life.

In my own work, I have employed both genetic and structural studies of proteins in order to investigate the mechanisms by which damaged DNA is replicated. While my studies were not directly related to evolution, as happens within any scientific paradigm, evolution served as an underlying foundation for the basis of my studies and motivated the questions I asked. For example, using DNA sequence alignments, it was found that both humans and yeast have a gene for the enzyme DNA

[47] Behe, Michael J. Darwin's Black Box, Free Press, 2006.
[48] Peretó, Juli,Out of fuzzy chemistry: from prebiotic chemistry to metabolic networks, *Chemical Society Reviews*, 2012, 41: 5394-5403.

polymerase eta[49]. It is understood that these genetic sequences indicate an evolutionary relationship between humans and yeast and that the enzyme would serve a similar, if not identical purpose in both organisms. Since it was easier to obtain the yeast enzyme than the human enzyme, I worked with yeast DNA polymerase eta, with the goal of understanding how the enzyme works in humans. Finally, DNA polymerase eta has components of its protein structure that are not present in other DNA polymerases[50] . This additional component provides enhanced functions for the enzyme that are not observed in the other enzymes[51] . This is understood to indicate the evolutionary progression of the enzyme, after it branched away from the common ancestor that was shared between all DNA polymerases. My work contributed to studies that investigated the nature of the enhanced functions of the enzyme. For both the genetic and structural studies, the underlying assumption was the evolutionary relationships between humans and yeast. If I were to question the underlying validity of evolution, it would undermine the basis of my scientific investigations. As I was trained to interpret data in this paradigm, it is not possible for me to understand science without this framework.

This leads to the conundrum that scientists with religious beliefs encounter within the religion-evolution conflict. It does not seem feasible to have an inherent trust in the science that one conducts if one's beliefs don't coincide with the underlying paradigm of the discipline. The anti-evolution message that is often proclaimed among evangelical Christians, while motivated by the desire to be true to scripture, suports the thought that science is not to be trusted. On the other hand, anti-religious messages relayed by those without religious affiliations promote the concept that, for scientists, it is religion that cannot be trusted. How is a scientist expected to be true to both their faith and their discipline in an age of conflict between the two?

There are numerous papers, books, and speakers that have addressed the conflict between religion and evolution, each with a different perspective concerning the way this conflict should be addressed. Many of the publications have the sole intention of proving one model is better than the other: science is superior to religion or vice versa. There are also a few more moderate voices that attempt to find a balance between both evolution and religion. These perspectives are important in this relationship and authors such as Francis Collins[52], Kenneth Miller[53], and Darrell Falk[54], to name a few,

[49] Johnson, R.E., C. M. Kondratick, et al. "hRAD30 mutations in the variant form of xeroderma pigmentosum" Science, 1999, 285 (5425):263-5.
[50] Trinaco, J, et al. "Structure of the catalytic core of S. cerevisiae DNA polymerase eta: implications for translesion DNA synthesis," 2001, Molecular Cell, 8(2): 417-26.
[51] Acharya, N, et al. "Roles of PCNA-binding and ubiquitin-binding domains in human DNA polymerase eta in translesion DNA synthesis," 2008, Proceedings of the National Academy of Sciences, U.S.A., 105(46):17724-9.
[52] Collins, Francis, The Language of God: A Scientist Presents Evidence for Belief, Free Press, 2006.

should be considered. However, I want to continue with an historical approach with the goal of employing history as a model for religion and science overcoming tension.

Theological paradigms

In response to Kuhn's historicization of science, Hans Küng proposed a parallel model of theological paradigms in the development of theology[55]. Küng argued that, similar to science, theology functions within the context of a 'normal science' which determines the types of questions that are asked and the knowledge that is acquired. Data that does not coincide with a paradigm is typically ignored or made to fit in some way within the paradigm. Küng also indicated that, similar to natural science, adherence to a particular paradigm is a process similar to a conversion and selection of a particular theological paradigm is influenced by external factors. Unlike Kuhn's claim regarding natural science paradigms, Küng claimed that theological historicity must retain a fundamental continuity across paradigms. Essential to all Christian theological paradigms are the testimony of faith in Jesus Christ and the centrality of scripture; paradigm shifts within theology have not and must not involve a total break from these foundations of Christianity.

Küng identified five different historical theological paradigms: Alexandrian, Augustinianism, Medieval Thomist, Reformation, and Modern-critical. Changes from one theological paradigm to another coincide with the lifetimes of the individuals discussed above in the atomic theory narrative (Table 1). Origen, in the early church in the East, was the first to assemble a theology, in which his allegorical reading of scripture came to prevail, instituting the Alexandrian paradigm. In the West, Augustine was influenced by external factors, including his own conversion, crises within the church during his lifetime. His work resulted in the theological change to the Augustinianism paradigm, which included academic skepticism and incorporated allegories of the Alexandrian paradigm. Aquinas, influenced by the acceptance of Aristotle in Europe, initiated the change to the Medieval Thomist paradigm in the 13th century. The reformers of the 16th century altered viewpoints concerning the source of spiritual authority throughout the paradigm of reformation. Finally, the modern-critical paradigm, which developed with the separation of natural science and theology in the 19th century, has continued to progress into our current understanding of theology. It is evident that these theological paradigms have run a parallel path with and been influenced by paradigms in natural science.

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[53] Miller, Kenneth R. Finding Darwin's God, HarperCollins, 1999.
[54] Falk, Darrel R. Coming to Peach with Science, InterVarsity Press, 2004.
[55] Küng, Hans. "Paradigm Change in Theology", Paradigm Change in Theology, ed. Küng, Hans, and Tracy, David. The Crossroad Publishing Company, 1999.

Similar to paradigms in natural science, there are also smaller theological paradigms within the broader, over-arching Christian tradition. This leads to the question of whether or not literal interpretation of scripture, which is a main source of contention with evolution, can be considered a theological paradigm among fundamentalist Christians. It seems to me that it displays many of the characteristics of a paradigm: data that contradicts a literal interpretation is resisted or ignored, many questions that are explored within a literal framework may be meaningless outside of this perspective, and transition to or away from a literal interpretation is similar to a conversion experience.

While others may dislike the notion that both science and religion are socially constructed, this historicization of both science and theology has opened the door for me to resolve the tensions I've experienced in my own life. Realizing that theological paradigms have changed over the course of history has provided the final bit of evidence to sway my conversion away from the paradigm of biblical literalism that I was trained in. The key to this change, however, is Küng's insistence on the continuity of the central role of Christ and the centrality of scripture be retained in any new Christian theological paradigm. Adherence to a new paradigm, therefore, is not rejection of the underlying principles of Christianity and allows for a peaceful resolution between my scientific and theological understanding of the world.

Changing Paradigms: Conflict Resolution between Science and Religion

If biblical literalism is characterized as a theological paradigm, then the conflict between evolution and Christianity is best described as a conflict between a scientific paradigm and a theological paradigm; the conflict may be alleviated by a change or shift in one of the paradigms. Herein lays the difficulty of resolving this conflict: inherent in the structure of a paradigm is the resistance to change until an insurmountable body of evidence contradicting the paradigm is accumulated. As it stands right now, Ronald L. Numbers, who has studied the history of creationism[56], claims that such a change is not likely to occur anytime soon for either religion or science[57]. The evolutionary paradigm is currently accumulating evidence that supports evolution. There are still several gaps in knowledge concerning evolution, but little evidence that directly contradicts evolutionary theory, suggesting that the evolutionary paradigm is not poised for a change or shift.

Conflict a Result of Scientific Paradigms Integrated into Theological Paradigms?

[56] Numbers, Ronald L. The Creationists: From Scientific Creationism to Intelligent Design, Harvard University Press, 2006.

[57] Numbers, Ronald L. "Scientific Creationism and Intelligent Design", The Cambridge Companion to Science and Religion, ed. Peter Harrison. Cambridge University Press, 2010.

Both Aquinas and Gassendi demonstrated that it is possible for a theological paradigm to change in response to the influence of a scientific paradigm. Aquinas made room for Aristotelian philosophy by accommodating the components that were incompatible with his theology. Gassendi argued for the acceptance of Epicureanism within the Christian understanding of the natural world by altering the parts of Epicurean philosophy that were incompatible with Christianity. For both models, the key factor is that in the 13th and 16th centuries, natural science and Christianity were tightly integrated. Theology was forced to acknowledge changes in natural science and vice versa. In the current climate, science and religion are separate disciplines; there is less need for one discipline to change in response to changes in the other. Aside from alleviating the conflict and warfare mentality, it seems there is little incentive for biblical literalism to accommodate evolution into its theology the way that Aquinas established the Thomistic paradigm. In a manner similar to Gassendi, the Intelligent Design (ID) movement has made attempts to alter the scientific content of evolution to better fit theology. Within the scientific community, the ID movement has been largely met with resistance and little respect for its validity as a scientific theory.

Stephen Toulmin has argued that, in history, the direct integration of natural science into theology has led to serious conflicts within Christianity[58]. Toulmin cites the integration of Aristotle and the 'Argument from Design', which was based upon Newtonian physics in the late 19th century, as two situations where theologians failed to foresee that scientific paradigms might eventually be overturned. With the rapid scientific shifts away from those paradigms, theology was left unprepared to deal with those changes.

I propose that the current conflict between evolution and Christianity is the result of a similar situation; a paradigm change in science that has left Christianity with the issue of a theology built upon a scientific paradigm that has been abandoned. As demonstrated by Gassendi's, Boyle's, and the other Empiricists *presuppositions* of God as creator, nature in the 16th and 17th centuries was understood as creation. These adherents of voluntarism, which provided a religious means of *regulation of scientific methodology*, established a scientific paradigm that provided a static understanding of creation that was well-described by experimental and mathematical models. With the paradigm shift to an evolutionary view of the earth's history in natural science, the paradigm of biblical literalism has been left with a theological understanding of the world that is fixed and does not coalesce with our current scientific paradigm.

[58] Toulmin, Stephen. "The Historicization of Natural Science: Its Implications for Theology", Paradigm Change in Theology, eds. Küngs, Hans, and Tracy, David. The Crossroad Publishing Company, 1999.

If theology is to avoid similar patterns in the future, Toulmin has proposed that theology should not be fundamentally based upon any scientific paradigm:

> "So the call for 'new paradigms' in theology should not ask us to assemble the more up-to-date scientific ideas of a post-Darwin, post-Einstein, post-Freud era into a novel cosmological construction that claims the same fundamental authority and permanence that were claimed for Aristotle and Newton earlier. That will simply lay up fresh trouble for theology a century or two down the road, when scientists have rethought the problems of their own disciplines, to the point of making radical changes for which theologians would once again be ill prepared. It may well be the case, indeed, that theology can hope for no secure and permanently reliable foothold in the natural sciences, at least on the abstract, theoretical level. If that is so, it will be better if theologians heed the sceptics, free themselves from the seduction of 'new paradigms', and become frankly reconciled to being (in that sense) 'paradigmless'. It will be better if they distance themselves from the ideas of science rather than embrace them too systematically and uncritically."

Toulmin's opinion described here is very important to consider for the sake of future of Christianity. Understanding the historicization of science and theology makes it clear that integration of the disciplines allows for potential conflict in the future. Thus, in the broader context of Christian theology, not just biblical literalism, we must proceed cautiously, taking time to examine and reflect upon the construction of theological principles.

Fruitful and Unfruitful Interactions between Science and Religion

In his seminal work, Religion and Science, Ian Barbour suggested that relationships between science and religion can be categorized into four types of interaction: conflict, independence, dialogue, or integration. As I've already discussed, the current situation between religion and evolution is an example of the conflict model: adherents to atheistic evolution and biblical literalism both believe that rival claims have been made regarding the nature of life's origins. Thus, from these extreme viewpoints, an individual can only choose to ascribe to one of the claims. On the other end of the spectrum, the Aristotelian synthesis into Christian theology is an example of Integration, which claims that scientific and theological content can find direct connection to each other. For reasons described above, I don't think that the Conflict or Integration types of interaction present acceptable and sustainable options for the future of science and Christianity.

Independence, as defined by Barbour, avoids conflict by claiming that the realms of science and religion do not overlap. Each inhabits its own independent sphere without influence from the other. Stephen Jay Gould, an evolutionary biologist, is a proponent of this model, in which he describes science

and religion as two non-overlapping magisteria, or areas of authority for teaching[59]. According to Gould, the magisterium of religion deals with purpose and moral values while the scientific magisterium addresses the empirical realm of fact and theory. Neither science nor religion should be consulted for expertise outside its realm. In this way, Gould allows room for religion and science to peacefully coexist without overlap or contradiction.

It seems that independence between science and religion is the type of interaction that science has been striving towards since the desacralization of science in the 19th century. Furthermore, Gould's model of independence between two magisteria is particularly attractive in light of evolution. This allows evolution to explain physical origins of life while leaving room for religion to describe spiritual origins. In a broader context, independence between science and religion avoids the potential pitfalls of scientific and religious paradigms being founded upon each other. Toulmin's suggestion for a Christian theology that is removed from scientific paradigms could easily be accomplished in this model. It's not surprising, then, that many religious scientists are adherents of the independence type of interaction between their spiritual and scientific lives. There are occasions when I find myself reverting to a model of independence, by claiming that the Bible is not intended to be a scientific textbook.

Yet, in my opinion, independence between science and religion presents several problematic issues. First, evolutionary theory not only provides descriptions of the origins of life, it offers rational explanations for issues that are just as easily defined as theological issues. For example, evolution offers a rational explanation for evil in the world. Evil is unequivocally categorized as a philosophical and theological issue. Thus, in some respects, it is certain that science and religion will overlap. Secondly, humans are integrative beings and complete compartmentalization of theology and science in one's own life is not easily accomplished. Finally, independence between these disciplines does not allow room for the Christian doctrine of divine immanence in creation.

Therefore, I propose that dialogue between science and religion is the type of interaction between science and religion that holds the most promise for the future of both disciplines. Dialogue involves the recognition of a relationship between religion and science, without integration of the two disciplines. Both science and religion are recognized as disciplines with their individual roles, but it is understood that overlap exists between the two. Thus, a theology that is aware of and interacting with

[59] Gould, Stephen Jay. Rocks of Ages: Science and Religion in the Fullness of Life, The Random House Publishing Group, 1999.

current paradigms in science, but is not founded upon them, is promising as a conflict-free model of interaction between science and religion.

Redefining Natural Theology

There are a variety of theological approaches that are easily categorized as dialogue between science and religion and it is not feasible to address each one. However, given the historical perspectives of relationships between natural philosophy and theology discussed in this paper, it seems fitting to propose a reformulation of an historical relationship between these two disciplines: natural theology.

Since the Enlightenment, natural theology has been understood as the enterprise of arguing for the existence of God through nature, without an appeal to divine revelation[60]. In other words, natural explanations that did not presuppose any religious beliefs were used to argue for a religious God. The Boyle lectures, as described above, are a great example of this expression of natural theology. Lecturers in this series understood God as the only logical explanation for the evidence that nature provided. Interestingly, though, as time and science progressed, later lecturers in the series began to appeal to less orthodox forms of Christianity through natural theology. Ultimately, natural theology defeated the purpose of the Boyle lectures, as it did not effectively demonstrate the "reasonableness" of the Christian God[61]. This appeal to natural theology is best defined, according to Barbour's typologies, as Integration and ended up hurting, rather than supporting Christianity.

Alister McGrath, in his book, The Open Secret[62], has proposed a revision of natural theology in an approach that represents a potentially productive dialogue between natural science and theology and fits well within this discussion of the paradigmatic relationships between them. In this approach, McGrath makes the case that, with the current waning of modernity, now is an appropriate time to reflect upon and examine relationships between religion and natural philosophy. Building upon his previously developed critical realist approach to theology[63], his intention is to lay the groundwork for a more enriched and active meeting ground for Christian theology and the natural sciences through a redefinition of natural theology. In this approach, McGrath proposes an intentionally Christian natural theology, historically founded in the life and death of Jesus Christ, which provides an interpretive framework from which to understand nature. The incarnation, he argues, is the primary example of how

[60] Topham, Jonathan R. "Natural Theology and the Sciences", The Cambridge Companion to Science and Religion, ed. Peter Harrison, Cambridge University Press, 2010.
[61] Henry, John. "Religion and the Scientific Revolution", The Cambridge Companion to Science and Religion, ed. Peter Harrison, Cambridge University Press, 2010.
[62] McGrath, Alister. The Open Secret, Blackwell Publishing, 2008.
[63] McGrath, Alister. A Scientific Theology: Reality, William B. Eerdmans Publishing Conmpany, 2002.

the transcendent can be revealed through nature, if interpreted from the correct framework. Nature, he argues, is an open secret that is available to all, but revealed only when seen from a Christian theological perspective.

Rather than attempting to prove the existence of God, McGrath intends for natural theology to investigate the way in which human beings, through reflection upon our current understanding of nature and natural processes can discern the transcendent:

> "The agenda is not therefore "proof" of core Christian beliefs, but the demonstration of resonance between theory and observation, leading to an enhanced commitment to the theory that is able to explain and account for so much that is observed."

This approach is to insist that the current understanding of the natural world *resonates* with a Christian understanding of a creator God. How we make sense of our world plays an integral role in the development of a Christian natural theology. This sense-making includes, but is not limited to, empirical data, mathematical models, and scientific theories. This approach affirms the capacity of the human mind to make sense of its surroundings, but is not restricted to or defined by such activities. This Christian natural theology, therefore, is aware of and respectful of natural explanations that are currently available, but are not founded upon or dependent upon such descriptions.

McGrath's discussion regarding natural theology and truth demonstrates respect for natural descriptions in existence and for those to come. He makes no attempt to refute or disprove any natural description. Instead, his proposed natural theology allows room for respectful discourse between theology and natural science, devoid of the potential danger of establishing a theology that is integrated into the current scientific paradigms. Of course, this is an initial work proposed by Alister McGrath, requiring continued discussion for development and establishment of such a Christian natural theology. It is, however, a promising example of the type of healthy dialogue that might be established between the natural sciences and Christian theology and thus alleviate the current tensions between evolutionary biology and Christianity.

Summary

In this paper, I have explored the historical figures and the contexts within which the concept of atoms was initially developed, rejected by the Christian church, and eventually accepted as a scientific theory. In light of this narrative, I have proposed that logic behind such events is best understood in light of the scientific and theological paradigms of each time period. We have seen that conflict arises between religion and science when a theological paradigm is established upon an existing scientific

paradigm that shifts without a similar change in theology and I have claimed that the current conflict between evolution and biblical literalism within Christianity is an example of such a paradigmatic problem.

I have proposed that, in order to alleviate current and future conflicts, science and religion would benefit by adopting the model of dialogue between the two disciplines. I've specifically described Alister McGrath's new vision of natural Theology and the promise this approach gives for productive and healthy interactions. As this is not yet a well-defined approach, I expect that such a Christian natural theology should take a considerable length of time to develop, allowing adequate discourse between Christianity and the natural sciences to establish an appropriate dialogue. A resulting relationship of mutual respect will greatly increase the likeliness of our seeing the resolution of the current conflict between evolution and Christianity.

Natural Philosopher	**Religious Influence on natural philosophy (defined by Brooke)**	**Scientific Paradigm**	**Theological Paradigm**	**Role of Philosopher**
Origen (184-254 CE)		Greco-Roman	Alexandrian	Viewed nature as source for allegorical readings of scripture
Augustine (354-430 CE)	*Motivation*		Augustinianism	Viewed natural philosophy as 'handmaiden to theology'
Aquinas (1225-1274 CE)	*Criteria for selecting between models*	Aristotelianism	Medieval Thomist	Accommodated Aristotle's philosophy to fit Christianity
Gassendi (1592-1665 CE)	*Criteria for selecting between models* *Presuppositions* *Regulation of Scientific Methodology*	Scientific Revolution--> Empiricism	Reformation	Altered Epicurean philosophy to fit theology
Boyle (1627-1691)	*Presuppositions* *Regulation of scientific methodology* *Sanctions* *Motivation*			Eliminated atheistic reputation of atomism
Dalton (1766-1844)		Newtonian	Modern-critical	Operating in secularized science

Table 1. The key philosophers involved in the development of atomic theory and the influence of Christianity upon natural philosophy, as defined by John Hedley Brooke, that each demonstrated. Included in this table are the scientific and theological paradigms that predominated the time in which each individual lived.