# PERSPECTIVES on Science and Christian Faith

## JOURNAL OF THE AMERICAN SCIENTIFIC AFFILIATION

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Order from Chaos

The Evolution of Creation Science, Part 3: Natural Selection and Convergent Evolution

"The fear of the Lord is the beginning of Wisdom." Psalm 111:10

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## **Editorial**

## A View from a High City



James C. Peterson

am writing to you from the annual meeting of the American Scientific Affiliation that founded this L journal. We are meeting this year at the Colorado School of Mines in Golden, just west of Denver. Denver has long been known as the Mile High City, and has doubled down on that reputation with the legalization of recreational marijuana. Golden has its own provision for intoxication as the home of MillerCoors, the brewing company. I have not regarded this meeting locale as an opportunity to seek out legally spiked brownies. My theory is that there could be no good result from trying them. If I do not like their effect, it would be a waste of time and money. The alternative, that I might discover that I like them, would be the worst case scenario. While many new experiences can be fascinating or a delight, would this one be worth the risk of being drawn to, or maybe even psychologically or physically hooked on, a substance that is illegal where I live?

And beyond legality, for many, these and other substances quickly become deeply addictive. How many lives have been sapped, crippled, or even lost over one addiction or another? One may hope to toy safely with substances that are not always addictive, but how does the person experimenting know in time, which ones will become deadly for him or her? Circumstances and susceptibility dictate that the danger ranges from hard to impossible, to predict. And indeed addictions can become deadly. Deaths from addiction to prescription opioids, fentanyl, heroin, crack, and alcohol fill the obituary columns even when the cause of these deaths is not specifically noted. Legal nicotine has one of the most compulsive and deadly records of all. And behavioral addictions such as gambling and pornography stagger individual lives and our society in their own way as well. Why do so many bright and able people harm themselves and others, often against their best intentions?

Can we gain some insight here from both Romans 7 and neurology? We need "all hands on deck," all the help we can get, including that available from the best of Christian theology and the sciences. The sciences, social sciences, humanities, and theology interact at this juncture with lives at stake.

Judith Toronchuk gets us started working together on this challenge with her invitation essay posted on the web pages of both ASA and CSCA. Toronchuk (PhD, McGill University) teaches physiological psychology at Trinity Western University. Her essay informs readers of the latest developments in addiction research, and raises key questions for our understanding and response. Readers are encouraged to take up one of the insights or questions that she raises, or maybe a related one that was not mentioned, and draft an article that contributes to the conversation. These can be sent to her at toronchu @twu.ca. Tornochuk will send the best essays on to peer review, and then we will select from those for publication in a theme issue of *Perspectives on Science* and Christian Faith (PSCF).

The lead editorial in the December 2013 issue of *PSCF* outlines what the journal looks for in article contributions. That piece, along with all other *PSCF* content published more than nine months ago, is available through an index at http://network.asa3 .org/?page=PSCF. For best consideration for inclusion in the theme issue, manuscripts should be received electronically before October 31, 2017.

Looking forward to learning from your contributions, **James C. Peterson**, *editor-in-chief* 

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## **Article**

## Science and Christianity Conflicts: Real and Contrived

Pablo de Felipe and Malcolm A. Jeeves

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 lists, bleeding and crushed if not annihilated; scorched, if not slain. (Thomas H. Huxley, *Darwin on the Origin of Species*, 1860)<sup>1</sup>

One typical "knee jerk" answer to the question, "What is the relation between science and religion?" is, "There is a conflict." The roots of this widely held response go deep. It is easy to select historical examples to justify it and arrive at a narrative in which religion (and here we study, in particular, Christianity) is driven into permanent retreat by science. However, using a different set of historical examples, it can be argued that, at times, Christianity, under the guise of a foe, did the work of a friend for science. The conclusion of a wealth of historical information is that a "conflict-retreat" portrayal of science-religion relations tells only part of a story that, in fact, is much more complex.

Science has become a definitive part of contemporary culture. As this has happened, awareness of the narrative of the history of science has become a key element in explaining how we have arrived where we are today. In understanding science and religion relations, historical examples provide crucial insights.

In 1990, Ian Barbour proposed a fourway classification of the relationship between science and religion: conflict, independence, dialogue, and integration.<sup>2</sup> Although other classifications have been proposed, Alister McGrath, another leading figure on science and religion, has argued that "despite its limitations, the framework set up by Barbour remains helpful."<sup>3</sup>

Relevant here is his identification of conflict as the most pervasive way of representing the relation between science and religion. McGrath makes it clear that the conflict and warfare themes have continued to be important. He writes,

... some scientists and religious believers see them as locked in mortal

combat: science and religion are thus at war with each other, and that war will continue until one of them is eradicated.<sup>4</sup>

However, he also reminds us that this warfare metaphor "is not seen by historians of science as being particularly reliable or defensible"<sup>5</sup> as "the relationship between science and religion has always been complex."<sup>6</sup> The complex nature of this relationship has been defended and studied in detail for decades.<sup>7</sup>

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Pablo de Felipe



Malcolm A. Jeeves

## **Article** *Science and Christianity Conflicts: Real and Contrived*

In a recent paper, McGrath has observed that

to those in the know, this "science versus religion" narrative is stale, outdated and largely discredited. It is sustained not by the weight of evidence, but by endless uncritical repetition, which studiously avoids the new scholarship which has undermined its credibility.<sup>8</sup>

An example of how better awareness of the history of science can illuminate science-religion relations is the 1989 work of historian Colin A. Russell, who criticized what he called "the widespread myth of an endemic conflict between science and religion," whose origins he located in the late nineteenth century.9 He claimed that this "conflict metaphor," as he called it (which has also been named as "warfare model," "conflict thesis," "military metaphor," "conflict model," etc.), "is not an assertion in the philosophy of science but rather in history of science, alleging what actually happened in the past and continues to the present day."10 In studying the foundations of this conflict model, Russell pointed out that "the evidence points strongly in the direction of a myth conjured into being on the slender basis of a few causes célèbres [...]."11

More recently, another historian of science, John Henry, has pointed out how some *causes célèbres* (he mentioned the Copernican revolution, the Galileo affair and Darwinism) "are too often regarded as demonstrating clearly and irrefutably that science and religion just do not mix, and indeed are essentially incompatible with one another."<sup>12</sup>

## A Conflict-Retreat Model for Science and Religion

In this article, we wish to illustrate how these *causes célèbres* are frequently used to foster one specific variety of the conflict model that claims that science and religion are locked in a perennial conflict, and that there is a progressive historical "retreat" of religion in this conflict. This view comprises three core beliefs:

- 1. A conflict between "science" and "religion" (in general terms) is inevitable, as both compete for the same territory;
- 2. This is an age-old, perennial conflict; and
- 3. In this battle, "religion" is in an inevitable retreat, losing ground in the face of the victorious advance of "science."

Certain key historical episodes have prompted this view. Our focus here is on Western Christianity, as historically this is the usual context for this conflict model, and the context in which we ourselves live and work. In some cases, Christians have enlarged the dominion of "religion" to compete for the territory of science. To a certain extent, there was not only an interest in controlling scientific ideas per se, but also a question of authority related to the desire of the Christian churches to buttress their authority in as many fields as possible. At other times, Christians unfortunately indulged in a god-of-the-gaps approach between religion and science, in which scientific gaps were improperly filled with references to God. In due time, these occupied territories were reclaimed by science; hence, the inevitable retreat. Indeed, theologians themselves have criticized the godof-the-gaps as a false god that is indeed in retreat. Dietrich Bonhoeffer wrote most perceptively in 1944:

If in fact the frontiers of knowledge are being pushed further and further back (and that is bound to be the case), then God is being pushed back with them, and is therefore continually in retreat. We are to find God in what we know, not in what we don't know.<sup>13</sup>

This "conflict-retreat" model could be seen as a refinement of the general "conflict model" for science and religion relations. Some presentations of the conflict model do not have a historical angle and are content with an epistemological argument for incompatibility along the lines of the above point 1. It is interesting to mention that to see science and faith as competing, it is necessary to consider them as separate domains-something that was not so until two or three centuries ago. The history of their separation has been recently charted by Peter Harrison.<sup>14</sup> In this regard, we have used, throughout this article, the words "science" and "scientists" for historical periods from the ancient world to our own time. This has been done for the sake of simplicity, but Harrison's observation should be taken into consideration, as an additional layer of complexity, in that the professionalization of science became a reality only in the nineteenth century.

In other cases, we can see the history of science (and religion) enlisted to portray, as Russell pointed out, not just a metaphysical/ideological conflict, but a historical continuous combat (like a trench warfare), giving this purported conflict a centenarian or even millennial-deep perspective, as suggested in point 2, that illustrates the inevitability of such a conflict. However, many proponents of the conflict model go further and combine the idea of a historical conflict with the idea of scientific progress (point 3 above) to add directionality and create a historical account of a purported long struggle of science to free itself from the shackles of a retreating religion! In the recent words of Harrison,

The history of Western thought is understood in terms of a protracted struggle between these opposing forces, with religion gradually being forced to yield more and more ground to an advancing science that offers superior explanations. Wherever possible, religion has resisted this ceding of territory, thus hindering the advance of science.<sup>15</sup>

The way this struggle is framed is by picking selected examples of science-Christianity conflicts (those socalled causes célèbres) that are historically aligned and in which Christianity is predictably subjected to an inevitably continuous retreat in the face of the triumphant scientific fire, thus making a case for this enduring struggle between science and Christianity. The enumeration of examples such as the debates surrounding Galileo or Darwin, or others, marching in historical chronological progression, is enough to create by itself the impression that there is a connecting thread among them all, a continuous pressure to push Christianity out of the frame by progressive scientific achievements.<sup>16</sup> Of course, this argument has a moral: the long battle will continue until the annihilation of the retreating religious enemy is complete, and until an idealized future with science free of religious interference is achieved. This can be considered as reminiscent of Comte's view of directionality in human history.17

In the abstract of a seminal 1987 paper, David C. Lindberg and Ronald L. Numbers pointed to the need to contest the traditional examples, the *causes célèbres*, of the conflict model throughout history:

Recent scholarship, however, has shown the "warfare" thesis to be a gross distortion—as this paper attempts to reveal, employing illustrations from the patristic and medieval periods and from the Copernican and Darwinian debates.<sup>18</sup>

Apart from debunking many false pseudo-historical details in the "conflict" literature, the main straightforward method of confronting such biased historical reconstruction is to realize that these debates were hardly "science vs. religion." As a host of historians have shown, in each of these occasions, there were Christians and frequently even scientists (as well as persons who combined both trainings) on *both* sides of the argument, as in the case of Galileo:

The Galileo affair [...] was not a matter of Christianity waging war on science. All of the participants called themselves Christians, and all acknowledged biblical authority. This was a struggle between opposing theories of biblical interpretation: a conservative theory issuing from the Council of Trent versus Galileo's more liberal alternative, both well precedented in the history of the church.<sup>19</sup>

However, we would like to go further and argue that by selecting those particular historical examples, an agenda is already set that is designed to reach the conclusion that there is a conflict, consisting of a continuous retreat of the positions of Christians, who "got it wrong" on science. Using a different set of historical examples, we suggest that this has not always been the case. As an example, we can recall the founding father of the Big Bang theory, the priest and scientist Georges Lemaître, who, during a visit to the US in 1933, affirmed that he had "no conflict to reconcile"<sup>20</sup> between his Christian faith and his scientific work. In cases like this, no trench seems to be lost by Christians and no retreat found. Similarly, other examples are offered, not with the intention to show that the opposite of the "conflict-retreat" model is the case, but rather, to indicate that the history of science and Christianity relations is more complex than what this model pretends to show.

## Learning from the Past: Unnecessary Family Quarrels

In the hands of a good narrator, the succession of clashes—almost always depicted with two contesting sides, and always with the same side (Christianity) shown defending nonsense views that were destroyed by science—promoted an irresistible moving narrative: in short, a victorious science pushing a defeated religious enemy that would be smashed and would retreat time after time and eventually fade away and disappear.

In support of the science versus Christianity narrative, four episodes are typically described: (1) in the ancient/patristic times, the debate over the shape of the earth; (2) in the medieval times, the denial of the antipodeans; (3) in the modern era, the debate on the movement of the earth; and, finally, (4) in contemporary times, the rejection of evolution. In all

## **Article** *Science and Christianity Conflicts: Real and Contrived*

these cases, we are told that Christianity finally had to abandon its formerly held positions/trenches and retreat, recognizing the authority of science over the disputed ground until a new conflict broke out at the new science/Christianity border.

However, a strong case can be made that more careful research of these oft-repeated historical episodes shows a much more complex picture, one that resists these simplistic and neat battleground realignments.

#### *The Ancient/Patristic Age: Christian Flat-Earthers*

The sphericity of the earth was already known by Plato's time in the early fourth century BC and became the standard view during the Hellenistic and Roman periods, enshrined in the geographical and astronomical work of Ptolemy in the second century AD. Although popularizers still believe that the cosmological view of ancient (and even medieval) Christians was that of Cosmas Indicopleustes's flat-earth/chest-shaped universe, we can find in his own time (sixth century) criticisms of his views from Christians: the Alexandrian philosopher/scientist/ theologian Philoponus (sixth century), the Armenian scientist/mathematician Anania Shirakatsi (frequently known as Anania of Shirak, seventh century), and the Patriarch of Constantinople Photius (ninth century). Cosmas enlisted several quotations from earlier Christian writers to support his position, mainly connected with the particular theology of the School of Antioch, which by Cosmas's time had become the stronghold of Nestorianism. However, it is interesting that although Cosmas had predecessors, he had hardly any disciples. Even though his texts survived in the Eastern Mediterranean and were copied in the medieval and modern times, it is important to note that they went unnoticed in the West until translated into Latin and printed in the eighteenth century.

The only ancient Christian flat-earth author that was well known in the West was Lactantius, who in the fourth century mocked the sphericity of the earth, although, interestingly, not on theological grounds. Later, Augustine (fourth-fifth centuries) and Isidore (sixth-seventh centuries) were sometimes not completely clear about the sphericity of the earth. However, they neither denied the sphericity of the earth and never defended a flat earth, as did Lactantius and Cosmas, while Cassiodorus (fifth-sixth centuries) recommended the work of the prominent Roman astronomer and geographer, Ptolemy, to his monks and also mentioned a translation, now lost, by his contemporary Boethius. Starting with Bede (seventh-eighth centuries), a consistent exposition and defense of the sphericity of the earth was clear in Western Europe and made its way into university teaching.<sup>21</sup> Nobody in the Middle Ages took notice of Lactantius's rejection of the sphericity of the earth.

### The Medieval Age:

### Augustine against the Antipodes

Much more complicated problems were posed by the possible existence of the antipodeans (i.e., humans who lived on the opposite side of the earth). While they were an impossible race of people for flatearthers, the acceptance of the sphericity of the earth did not necessarily imply by itself the existence of dry land on the other side of the earth, and even less that it was populated by "antipodeans." In fact, the idea of a symmetrical continent on the other side of the earth had no scientific or historical basis.<sup>22</sup> Therefore, there were plenty of non-Christian writers who rejected it (such as Lucretius; see also references to this rejection in Pliny, Plutarch, and Lucian) or ignored it as in the case of geographers (e.g., the second-century Alexandrian Ptolemy, who concentrated his efforts in describing the known world: the Euro-Asian-African landmass or "oikoumene").

Although the earliest Christian mention of the antipodes by Clement in the late first century seems to have accepted their existence, later when Augustine famously denied the existence of antipodeans, he did so, not in association with a flat earth, as previously Lactantius and later Cosmas, but on the basis of the lack of historical evidence, the speculative nature of the "symmetrical" argumentation for the antipodes/ antipodeans, and, finally, on the theological threat of having humans that could not be descended from Adam or Noah. Nothing changed in the scientific/ geographical knowledge during the next millennium that could move the argument forward. The issue was resolved on empirical grounds (as it should be) during the age of exploration by Portuguese and Spanish seafarers in the fifteenth-sixteenth centuries. They found both: continents in the antipodes-although not arranged in a symmetrical way as Crates expected-and antipodean inhabitants on them.<sup>23</sup> Interestingly, the discoveries did not imply any of Augustine's feared theological problems, as it was soon realized by the Spanish Jesuit José de Acosta in the late sixteenth century that humanity remained a single species, with the inhabitants of America and Oceania related to the Asian people.

#### *The Modern Age: Galileo and the Inquisition*

Again, in the seventeenth century it is simplistic to speak of Galileo vs. the Inquisition as science vs. Christianity. In fact, in the 1616's condemnation of Copernicanism, the three books condemned were written by churchmen-Nicolaus Copernicus, Diego de Zuñiga, and Paolo Foscarini; and even more tellingly, the publication of Copernicus's De Revolutionibus had been urged by several friends of the author, all clerics: Bishop Paul von Middelburg, future Bishop Tiedemann Giese, and Cardinal Nikolaus von Schoenberg, and dedicated to Pope Paul III. On the Protestant side, several people, such as the mathematician Rheticus and the theologian Osiander, contributed to the publication of the book in the city of Nuremberg. Later, in the 1633 trial of Galileo, on the one side, his judges rightly considered themselves supported by the mainstream science of their age and also of the previous two millennia. On the other side, Galileo was supported by theologians and churchmen, including disciples such as the Benedictine mathematician Benedetto Castelli, and a helpful friend, the Archbishop of Siena, Ascanio Piccolomini, who hosted Galileo for several months at his palace after the condemnation by the Inquisition.

As with the antipodeans and Augustine, this was in the context of scientific evidence that was not at all clear at the time of Galileo. Although some of his discoveries such as the phases of Venus had ruled out the geocentric system of Aristotle/Ptolemy, Galileo was never able to completely discard the geo-heliocentric system of the sixteenth-century astronomer Tycho Brahe, a Lutheran who was followed with enthusiasm by the Jesuit enemies of Galileo, and he even declined to discuss it. Galileo thought that he had proven the Copernican system beyond doubt with his particular theory of the tides, which was probably his worst scientific blunder. It took another generation, and Newtonian mechanics, to discard Brahe's overcomplicated system in which all planets circled the Sun that in turn circled the earth, and to establish the Copernican system beyond doubt. As can be seen from this brief summary (and the quotation above corresponding to note 19), all the people mentioned were Christians, so the confrontation of science vs. Christianity does not help in understanding the situation.<sup>24</sup>

## *The Contemporary Age: Darwin and Christianity*

It is popularly assumed that the only response from Christians to Darwin's 1859 *On the Origin of Species* was that of a bitter and vicious opposition based on theological prejudices. However, detailed study of the contemporary reactions shows us at least three important and often overlooked considerations for the case we are making here.

First, some notable scientists at the time, although Christian themselves, opposed Darwin on real scientific grounds: for example, Adam Sedgwick, Charles Lyell, St. George Jackson Mivart, Louis Agassiz, and Richard Owen. The famous Anglican Bishop Samuel Wilberforce, an amateur scientist himself, has been universally mocked as the prototype theologian talking nonsense in a famous 1860 debate against Darwin's defender, T. H. Huxley. However, Wilberforce based his criticisms on scientific grounds, as can be seen in the critical review of Darwin's book that he wrote before the debate and published the following month. Darwin wrote about it to his friend Hooker: "It is uncommonly clever; it picks out with skill all the most conjectural parts, and brings forward well all the difficulties."25

The second conclusion is that Christian responses to evolution were not always negative: Babbage, 1837; Kingsley, 1859; Baden Powell, 1860; and Henslow (Darwin's mentor), 1860;<sup>26</sup> are telling examples. Babbage even proposed a sort of evolution long before Darwin (although we have to keep in mind that Babbage was, as the 1859 Darwin, closer to deism, and that not all Christians who accepted evolution supported Darwin's mechanism, in that it was based on natural selection). As with the previous examples from the medieval age and the modern age, this position has particular merit here, because, contrary to the assumed view, Darwin did not solve all the problems posed by his theory and had to face stiff opposition on purely scientific grounds (it took up to the twentieth century to solve some of these points). In any case, the study of Darwin's correspondence has shown that hundreds of his correspondents

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belonged to the clergy. During the rest of the nineteenth century, several Christian scientists were also supportive of evolution: Asa Gray, Charles Lyell (after initial criticisms), Aubrey L. Moore, James D. Dana, George F. Wright, and Alexander Winchell, as well as various well-known theologians: John H. Newman (Catholic), the Archbishop of Canterbury Frederick Temple (Anglican), Aubrey L. Moore (Anglican), James McCosh (Presbyterian), Benjamin B. Warfield (Presbyterian), Augustus Hopkins Strong (Baptist), and George F. Wright (Congregationalist). Furthermore, in recent times, there have been careful historical studies of what have been called the nineteenth-century Christian "defenders" of Darwin and evolution.27 And they continued active during the twentieth century (e.g., Teilhard de Chardin, Ronald Fisher, Theodosius Dobzhansky) and into our own days (e.g., Francis Collins, Francisco J. Ayala, Simon Conway Morris).

The third point we would like to stress is that, interestingly, Darwin himself did not show an aggressive anti-Christian position, even though he abandoned his Christian faith years before 1859. By this time he was a deist, believing in a Creator that had ordered the world by laws, as we will see below. Furthermore, while at an advanced age Darwin considered himself an agnostic, he still dismissed the inevitability of a science and Christianity conflict over evolution: "It seems to me absurd to doubt that a man may be an ardent Theist & an evolutionist."<sup>28</sup> In that view he was followed by none other than T. H. Huxley.<sup>29</sup>

## Aligning the Historical Examples of "Conflict" to Build the Conflict-Retreat Model

The rhetoric of science and faith conflict-retreat has not been built simply by accumulation of historical examples of conflict. Some authors have aligned them according to presumed historical parallels as a first step to the idea of directionality in the process that will be seen as moving toward the demise of religion. It is a known blunder of Freud that Darwin's removal of humans as the center of biology, by making us descendants of other animal species, parallels Copernicus's removal of humans' planet from the center of the universe. According to Freud, these were "two great outrages upon its [humanity's] naïve self-love."<sup>30</sup> In fact, Freud viewed himself as inflicting a third blow to humanity's pride by removing the core of the human personality from the conscious sphere to the unconscious with his psychoanalytic theory.<sup>31</sup>

This well exemplifies the idea of a continuous conflict with a retreating religion. However, it is an incorrect view of the historical events, not only in their individual description, but also in the way they are forced into a fictitious parallelism and progression. Copernicus did remove the earth from the center of the universe. But that was hardly a degradation for humankind, as the earth was considered from both physical and moral points of view as the bottom of the universe, its lowest and filthiest place. The center of the earth was also the center of the universe and was the abode of the devil and hell.<sup>32</sup> In contrast, with Copernicanism, humans were raised to the sky, to the abode of the planets that moved in perfect and divine circles closer to God. Among those thus welcomed was the new "planet" Earth.33 Freud was a victim of a historical anachronism ("Copernican cliché"), as in a very short time, between the sixteenth and the seventeenth centuries, a great intellectual mutation took place, reversing the importance given to the "center."34

If evolution challenged fixism in biology by introducing a dynamic history for the living beings, then the parallel challenge to fixism at the cosmological level was not heliocentrism, but the Big Bang theory that ironically developed during the lifetime of Freud. This new cosmology challenged the immutability and the eternity of the world, an idea that went back to Aristotle, and introduced a dynamic history for the universe at large. However, this parallel does not fit well in the conflict-retreat model of science against Christianity: whereas Christianity was used by some to resist heliocentrism, Christianity was suspected of promoting the Big Bang (see below). This explains why the birth of the modern Big Bang is omitted from the conflict models. What is even more interesting is that if we are to find a common pattern between heliocentrism, evolution, and the Big Bang, it is not in the retreat of Christianity, but in the demise of Aristotelianism (in its geocentricism, its fixity of species, and its eternally static universe).

It would, however, be a travesty of the truth to conclude this section by pointing out only adverse influences of Aristotelianism upon science. In the Middle Ages, Aristotelianism reinvigorated the Christian intellectual culture and stimulated an interest in science. However, modern science needed later to overcome its limitations (see below).

## Challenging the Hidden Agenda of the Conflict-Retreat Model

The overview given above shows how a robust response to the "conflict-retreat" model can be articulated on historical grounds. It is crucially important to mention that this clarification of the historical circumstances should not be used as an excuse to avoid acknowledging the mistakes of the past: there was indeed conflict in these examples. Twenty-firstcentury Christians should not feel obliged to defend or seek to justify the errors of fellow Christians of past centuries, and lessons must be learned from those mistakes to avoid future episodes of this kind. However, Geoffrey Cantor and Chris Kenny give an important observation: "Our main point is that while numerous conflicts have occurred, the conflict thesis is highly problematic as a general claim about the relationship between science and religion."35

The fact remains that by choosing these particular four historical episodes, the result was that the popular media and some outspoken anti-Christian authors (from the late nineteenth century to present days) set the *agenda* for most contemporary science and Christianity discussions. In this way, they take the initiative and choose a suitable battleground to justify their continuous "retreat" picture. Unfortunately, this conditions the science and Christianity dialogue, in the sense that most debates and propaganda on the historical relations of science and Christianity revolve around these few particular historical cases, even for those authors opposed to the conflict model paradigm. Indeed, Jason M. Rampelt has observed:

It is easy to see how one would be led to believe that there is a conflict if the only information before them were examples where scientific ideas destroyed religious ones (the immortality of the soul, Transubstantiation, physical resurrection, etc.). It has been less common to have examples of the doubly opposite case, that is, where science has not destroyed religion, but instead religion assisted in the growth of science.<sup>36</sup>

While the examples that Rampelt gave are not the ones that we might have chosen for a relevant historical overview, his point is nevertheless well made. We suggest that it is time to replace this paradigm not only by a more- or less-detailed refutation/clarification (as outlined above), but also by opening the windows to contemplate other historical episodes that illustrate an even more complex but more representative account of science-Christianity relations.

### Learning from the Past:

How Christianity, under the Guise of a Foe, Did the Work of a Friend for Science

To stimulate further debate, we offer instances in which Christianity does not seem to have "lost" any battle or "abandoned" any trench, inspired by the challenge formulated by John H. Evans and Michael S. Evans in a provocative way:

It is interesting to note that there is no literature (of which we are aware) of science influencing religion in which science is predicted to lose.<sup>37</sup>

By way of argument and illustration, we select four examples: (1) in ancient/patristic times, Augustine's criticism of astrology-his criticism was mainly based on the idea of human free will and on relevant empirical evidence (like the study of twins); (2) in medieval times, Philoponus's (and some medieval theologians and scientists) criticisms of Aristotelian physics/cosmology-their criticisms were based on the idea of creation and some particular scientific ideas (anti-Aristotelian mechanics); (3) in the modern era, the influence of Christian theology on the development of the modern concept of the laws of nature; and, finally, (4) in contemporary times, the birth pains of the Big Bang model, rejected by some scientists as the embodiment of the Christian idea of creation.

In all of these cases, the situation differs from what we saw before. However, these are not counterexamples in the sense of Christianity fighting against science and winning any battle. They can be seen rather as Christian faith supporting a matrix of ideas that contributed to the development of science (in particular, in examples 2 and 3), at the same time fighting some previous preconceptions, but ones that today we would not regard exactly as "science," for example, astrology and Aristotelian philosophical physics (examples 1 and 2). In example 4, the situation is more complicated, since the science of the Big Bang was not created in the name of Christianity, but was a development from Einstein's general theory of relativity. The problem was rather that some scientists were suspicious of the Big Bang theory as being too close to a Christian model of creation.

It hardly needs saying that we, as those engaged in scientific research for many years and who are enthusiastic about scientific progress, will not make a knee-jerk claim that "science" was defeated or

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retreated in any way. Playing with Moore's famous observation that Darwinism, "under the guise of a foe, did the work of a friend"<sup>38</sup> for Christianity, we suggest that at times, Christianity too, under the guise of a foe, did the work of a friend for science.

### *The Ancient/Patristic Age: Augustine's Anti-astrology*

While it is very common to find Augustine being criticized for his rejection of the antipodeans and for his unclear attitude to the sphericity of the earth, it is not so common to read about his views on astrology in the context of science and faith. Augustine, along with other Christian theologians both before and after him, proposed a well-thought-out series of objections to the popular beliefs about astrology. We should remember that astrology, having its origins in Mesopotamia, became common in the Hellenistic culture and later in the Roman Empire. Astrology was not separated from astronomy at that time, and both were supported by the top scientists of the time.

In spite of the acceptance of astrology and its inclusion in astronomy, some Christian authors, and Augustine in particular,<sup>39</sup> challenged astrology and criticized it on the basis of Christian ideas that can be seen as rooted in the Hebrew Bible and some later Jewish literature, as well as in the New Testament: (1) the defense of free will against deterministic astral fatalism, (2) the view that all things were not supernatural, including planets and stars, and were created under the dominion of the Creator, and (3) the criticism of idolatry, particularly the astral cultic practices. Very importantly, Augustine also relied on empirical arguments, going back as far as Carneades in the third-second centuries BC and other philosophers through Cicero (first century BC):<sup>40</sup> in particular, the divergent fates of twins<sup>41</sup> and the similarity in behavior (e.g., cultural customs) of entire nations that have no simultaneous birth of all their individuals. However, Augustine was able to recognize a material influence of the heavenly bodies on the earth (seasons, tides, etc.). Interestingly, it was the theologian Origen, another influential Christian critic of astrology (although he was willing to give more room for the astral influence on the material affairs on Earth than Augustine, centering his attack on the astral fatalism) who was the first to deploy an innovative scientific argument against astrology using the astronomical concept of the precession of the equinoxes attributed to Hipparchus.<sup>42</sup>

The enduring influence of Augustine on this topic dominated the medieval era, up to the Renaissance, when Giovanni Pico della Mirandola again combated astrology, following the ideas of Augustine.

It went to such a point the strength that he displayed, that the position of Augustine remained as the paradigm of the rejection of the Church to pseudoscience and it provided plenty of argumentation to those who, after him, attacked it again.<sup>43</sup>

Interestingly, and sadly, we have to say that for all the good insights that Augustine's criticisms provided, their general effect was minimal over the centuries on the large majority of the population. Things changed only toward the late seventeenth century, when scientists finally turned their backs on astrology for good (most notably Descartes and Newton)—although at a popular level astrology is still as strong as ever today.

It is an irony that ancient Church Fathers, frequently mocked in the conflict literature as ignorant and superstitious, could be closer at some points to what we regard as "science" today than those who, at the time, were supposed to be the expert "scientists" (e.g., Ptolemy). In ancient times, what today is science, philosophy, and religion-and even, at times, superstition-were all merged into a single body of knowledge, as in the Platonic or Aristotelian systems, and even more confusing in the Neoplatonic thinking of the late antiquity. The problem was that for common Christians, who were not trained in the study of the natural world, it was very hard to discriminate between things that differed. How, for example, could Lactantius know that the sphericity of the earth was sound knowledge and that astrology was not? Both were proclaimed by the top experts of Alexandria. Indeed, the same Ptolemy who wrote the great astronomical treatise Almagest and the Geography, also wrote the astrological classic *Tetrabiblos*. It is easy for us to see the difference in retrospect, but it had to be very hard for Christians of that era.44 It needed a Christian scientist/philosopher such as John Philoponus to clarify things. Although he criticized the divinity of the heavenly bodies, Philoponus was able to recognize that other ideas, such as the sphericity of the earth, had sound scientific foundations and should be retained by Christians (see below).

### The Medieval Age: Philoponus's Anti-Aristotelianism

A century after the "revolt of the medievalists," the medieval period is still sadly portrayed as the Dark Ages, reflecting, in fact, our own enduring ignorance about this millennium of history. If there is an area in which the imagination of today's generation believes that this age was particularly dark, it is in relation to science. A recent example is the film *Ágora*, which portrays the life and death, at the hands of Christian extremists in Alexandria, of the philosopher and mathematician Hypatia in 415, indicating that this was the end of ancient science.<sup>45</sup> However, the last glorious days of ancient Alexandrian science were to come in the sixth century with the much less popular figure of John Philoponus.

Educated by pagan philosophers who still taught in Christian Alexandria, Philoponus became the most prominent critic of Aristotle in antiquity. He particularly targeted aspects of Aristotle's physics and metaphysics. Sometimes, in debates, his criticisms that we would consider more philosophical/theological (eternity of the world vs. creation) were made in the name of Christian ideas. However, at other times, Philoponus combined ideas of theological inspiration with philosophical/scientific reflections in order to overturn some key aspects of Aristotelian science, as when he fiercely attacked the perfection of the heavens, defending the view that the heavenly bodies were of the same matter as the earth, comparing the sun with fire, and leading to a certain unification in science. All this scandalized the pagan philosophers, who considered the sun a divine being.<sup>46</sup> Philoponus also held other ideas of a scientific nature, which, although with some precedents among certain Greek scientist/philosophers, were almost forgotten by his time, and continued to be so until the late medieval and early modern periods, such as the possibility of movement in a vacuum and the idea of impetus to explain the movement of projectiles.47

To complete an extraordinary career, Philoponus made a vigorous defense of the sphericity of the earth against fellow Christians who denied it. He also mocked those who believed that the heavenly bodies were moved by angels (a Christianized concordist view based on pagan gods or "intelligences" which animated the heavenly bodies). Rather, he argued that it was God's initial creation that set them in movement until today. He even wrote a commentary on Genesis 1, *De Opificio Mundi*, in which he aired his views on science and Christianity.<sup>48</sup>

What was the impact of Philoponus? Most of his books disappeared, but his views were never forgotten. Although his pagan enemies criticized him as a dangerous anti-Aristotelian,<sup>49</sup> his influence survived in Eastern Christianity. In the ninth century, Photius praised Philoponus's commentary on Genesis 1.<sup>50</sup> The Muslims, soon after Philoponus conquered Egypt, preserved some of his ideas and transmitted them to the West, where some of his books were already printed by the sixteenth century.

A controversy among experts has raged in the late twentieth century to determine the extent of his influence on medieval and modern science. This has been a polemical topic with much ideological content fueling some debates. Of particular interest is his idea of "impetus," which resurfaced with some medieval Muslim scientists and also in Buridan at the University of Paris in the fourteenth century, and its potential relation with the modern concept of "inertia" (this latest connection is not generally favored by historians, although it helped to soften the dominance of Aristotle). Furthermore, the application of this idea to cosmology, and even to cosmogony, in the context of the Christian idea of creation, is not so different in Philoponus<sup>51</sup> and Buridan,<sup>52</sup> both of whom criticized the idea of planets moved by "intelligences" or angels.

Regardless of the extent of Philoponus's influence on medieval and modern science, what he did is sufficient for the sake of the argument we are presenting here. He was an example of a remarkable Christian thinker who does not fit the science and Christianity "conflict model." Indeed, it could be argued that his theology, rather than suppressing his science, helped it. It was a tragedy that circumstances prevented his ideas from becoming better known. Instead, medieval Christianity in the West followed Aristotle, who was non-Christian. Following him forced theologians to make difficult compromises in order to "conciliate" his ideas with Christianity. That paradox shows to what an extent medieval Christians, rather than suppressing ancient pagan knowledge, made all sorts of efforts to assimilate it, even against their own interests. Samuel Sambursky writes:

One is tempted to speculate on how the course of the history of ideas would have been changed had the doctrine of Philoponus been accepted by the

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Church instead of the Aristotelian conceptions. Had for instance Thomas Aquinas chosen Philoponus' ideas and incorporated them in the scientific foundations of Christian philosophy, the birth pangs of the Copernican and Galilean revolution would perhaps have been less severe and scientific progress possibly accelerated.<sup>53</sup>

### The Modern Age:

#### Creation and the Laws of Nature

One of the key pieces of Western European "modern" science, and one that was strongly advocated by the leaders of the scientific revolution of the sixteenth and seventeenth centuries, was the idea of the "laws of nature," still a fundamental notion in science today. Galileo, Kepler, Descartes, Pascal, Boyle, Newton, and Leibniz all shared the belief in the existence of laws imposed on nature, typically prescribed by a rational "lawgiver" God at the moment of the creation of the universe. Nature was docile in following these laws that were the same in any place, at any time, and independent of the human observer. Galileo, for example, explained it clearly in his public letters on science and Christian faith of the early 1610s:

For the Holy Scripture and nature both equally derive from the divine Word, the former as the dictation of the Holy Spirit, the latter as the most obedient executrix of God's commands; ... nature is inexorable and immutable, and she does not care at all whether or not her recondite reasons and modes of operations are revealed to human understanding, and so she never transgresses the terms of the laws imposed on her ...<sup>54</sup>

This idea was inherited from philosophical-theological views that can be traced back to the medieval age, with even earlier precedents: (1) the views held by some Greek/Hellenistic thinkers; and (2) the biblical view of God as the creator and lawful ruler of the universe. One particular verse that summarized this view, and has been cited over and over by Christian authors, is found in Wisdom 11:20b: "You, however, ordered all things by measure, number and weight."<sup>55</sup> Jewish and Muslim scholars shared these ideas with medieval Christians.

It seems that biblical theology on the concept of creation, and the relation between the Creator and its creation, matured during the medieval age and was a pervasive influence in developing the concept itself of the law applied to nature that crystallized later in the modern era. In parallel, Greek mathematics provided the scientists of the sixteenth and seventeenth centuries with the tools to find these laws. A further development was to fuse all these ideas and to bridge the Aristotelian gulf between natural philosophy and mathematical astronomy to obtain mathematical laws in physics. The idea of a rational/ mathematical Creator helped considerably to build that bridge. As the twentieth-century scientist Carl F. von Weizsäcker pointed out:

The concept of exact mathematical laws of nature which was only dimly present in Greek thought gained far greater convincing power by means of the Christian concept of creation ... it was a sort of Christian radicalism which transformed nature from the house of gods into the realm of law.<sup>56</sup>

A recent general study of the development of the concept of laws of nature by historian Peter Harrison points to that more specifically:

That there are laws of nature, however, seems to be a presupposition of science, rather than the outcome of its investigations. In light of this we can ask three important questions about such laws of nature: Why are there laws at all? Why are these laws mathematical? Why are they necessary or, to put it another way, what gives these laws their exceptionless character? In the seventeenth century, when the modern notion of laws of nature was first articulated, the answer to each of these questions entailed reference to God. The very idea of a law of nature, from the moment of its birth, was thus underpinned by theological considerations.<sup>57</sup>

Twentieth-century historians of science have pointed to a larger religious context in which some biblically based ideas contributed to the inspiration and support of modern scientists who often appropriated and customized them for their own goals:

- a desacralization/mechanization view of nature as it belonged completely to the created realm,
- the rationality of the Creator God that implied the rationality of the creation and humanity as part of the creation,
- the contingency of creation by the free will of God that considered the universe, not as a "necessary" being that could be understood by a priori abstract speculative thinking, but as a creation that has to be explored by experimentation in order to discover the precise laws chosen by God to govern it,

- the status of humans as a fallen image of God that implied the optimistic hope of unraveling the laws of nature imposed by the Creator, with a realistic dose of pessimism about human rationality and the suspicion, again, that rationality abandoned to itself was not sufficient to understand nature,
- a desire to recover the wisdom of "Adam" before the Fall that inspired the scientific activity to recover "dominion" over the creation, lost due to the original sin,
- a positive view of manual labor that favored experimental work, contrary to classical tradition, and was inspired by the Bible (in particular among Protestants, also in connection with the principle of the "priesthood of all believers"), and
- a more "literal" reading of the Bible that influenced a more straightforward reading of the "book of nature," contrary to the traditional "allegorical" reading in which one looked for moral allegories in nature (in particular among Protestants).<sup>58</sup>

If seventeenth-century physicists and astronomers sought to understand the physical universe with the concept of "laws of nature," it was none other than Darwin who, in the first page of *On the Origin of Species* (1859), at a time when he was no longer Christian but deist, still used the quotes of two Christian philosophers of science, Francis Bacon (1605) and William Whewell (1833), to advance an evolution of life governed by laws, while attempting to preempt criticism on religious grounds.<sup>59</sup>

## The Contemporary Age:

### Lemaître's Big Bang

The "consensus" view among scientists before the theory of relativity, regarding the history of the universe, was one of static eternity - in some ways, not different from the Aristotelian view-unchallenged on this point by the "classical" Newtonian physics. That was so even though, from a philosophical/theological point of view, Jews, Christians, and Moslems had traditionally been reticent to accept an eternal universe (we should remember here Philoponus), although later Aquinas defended the view that an eternal universe could be compatible with Christian theology.<sup>60</sup> However, as soon as Einsteinian relativity came along, it was clear that it had possible implications for views about the history of the universe. While Einstein himself supported a static model of the universe in 1917, the Russian mathematician

Alexander Friedmann proposed, in papers published in 1922 and 1924, alternative "dynamic" models of a nonstatic universe, including the possibility of an expanding, contracting, or oscillating universe.

In a famous 1927 paper, Georges Lemaître, a Belgian mathematician-physicist, defended again, independently of Friedmann who had died in 1925, a nonstatic universe; he also interpreted some astronomical evidence (red-shift of galaxies) to show that the universe is actually expanding. By 1931, Lemaître concluded that the expansion had a "beginning" or an "origin" in a "primeval atom" which had given rise to everything we now know: matter, energy, space, and time.

What was remarkable was that this proposal initially evoked an incredible visceral reaction, as some, including Einstein, felt a "biblical" flavor in the idea of an expanding universe. Of course, it did not help the early development of the Big Bang model that Lemaître was a Catholic priest. The opposition to the possibility of the Big Bang was fierce in some quarters, as the physicist von Weizsäcker remembered decades later a confrontation that he had had in 1938 with the old Nobel Laureate Walther Nernst regarding the origin of the universe:

He said, the view that there might be an age of the universe was not science. At first I did not understand him. He explained that the infinite duration of time was a basic element of all scientific thought, and to deny this would mean to betray the very foundations of science ... He was just angry, and thus the discussion, which was continued in his private study, could not lead to any result; ...

... I think, a deeply irrational trait of scientism was revealed in his view: the world had taken the place of God, and it was blasphemy to deny it God's attributes.<sup>61</sup>

The Big Bang model was relaunched at the end of the 1940s by the Russian scientist George Gamow (who studied under Friedmann and later emigrated to the US), only to be confronted with the same kind of criticisms, that this time went much further, to the point of giving rise to a counter-theory: the steady state model that, contrary to the first law of thermodynamics, postulated the continuous creation of matter to keep the density constant in an eternally expanding universe. It was precisely one of the chief advocates of the steady state model, Fred Hoyle, who coined the term "Big Bang" as a kind of insult!

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Probably the most remarkable aspect of this story is that Lemaître himself never used the Big Bang in Christian apologetics. Rather the opposite, he differentiated between the scientific idea of "beginning" for the universe and the philosophical-theological idea of "creation." He made public his views on science and Christianity relations in an interview to the *New York Times* in 1933 and in a lecture at the Sixth Catholic Congress of Malines in 1936, where he defended the idea – very much in line with what we saw in the previous section – that the main contribution of Christianity to science was

the advantage of knowing that the enigma has a solution, that the underlying logic is ultimately the work of an intelligent being, that, therefore, the problem posed by nature was posed to be solved, and that its difficulty is probably proportionate to our human abilities, be it today or tomorrow.<sup>62</sup>

Later, he famously disagreed with the "apologetic" use of the Big Bang by Pope Pius XII.<sup>63</sup>

In the end, the empirical finding of the microwave background radiation, a key prediction of the Big Bang model, by Penzias and Wilson in 1965, ensured the triumph of the Big Bang. Since then, we have seen, on the one hand, the rise in the "apologetical" use of the Big Bang in favor of "religious" worldviews, worryingly crossing the line that Lemaître did not want to cross. On the other hand, legitimate speculations on pre-Big Bang stages of the universe, or even the possibility of multiverses, are seen with suspicion among Christians. While Christians frequently have a skewed interest in the Big Bang apologetics, these other speculations frequently attract an inflated interest as "liberating" views from the inexorability of a Creator felt by many nonreligious people in the current situation. This is also a biased abuse of science. We should affirm science, and follow it wherever it leads without pressing it into a pre-defined "religious" or "irreligious" mold. Christian scientists should have the confidence to be at the front line in so doing.

### After the Conflict and Anti-conflict Models: Resetting the Agenda on the History of the Science and Faith Relationship

The popular idea of a conflict, a battle between science and Christianity, in which the latter is in a millennial-old retreat and losing ground to the former, is a modern tale, with a clear anti-Christian axe to grind. This conflict-retreat model, it seems, did not become popular until the final decades of the nineteenth century.<sup>64</sup> R. L. Numbers has traced its beginnings at least as far back as an 1845 article in a US newspaper in which it was stated: "Every new conquest achieved by science, involved the loss of a domain to religion."<sup>65</sup> However, this idea was already in the intellectual milieu of the Enlightenment.<sup>66</sup>

The conflict model is an oversimplification, since the history of science and Christianity relations shows a much more complex and richer story. The eight examples in the two sets of historical episodes discussed above tell us that these relationships can, at times, take unexpected twists. Therefore, general overarching historical models of friends and foes are inaccurate. If the idea of conflict as the explanation for science and Christianity relations is inadequate, then the use of historical episodes that give the impression of a historical directionality-that is, a Christian retreat under the marching of science, here described as a "conflict-retreat" model - is pure fabrication and manipulation of the evidence. Pointing to the fact "that one and the same scientific innovation could be given both sacred and secular readings," John H. Brooke has reached the conclusion that "the 'relations between science and religion' cannot be reduced to a simple pattern of religious retreat as the sciences advanced."67 In fact, one should be more critical and question even the possibility of any generalization, as Brooke himself pointed out years ago: "There is no such thing as the relationship between science and religion. It is what different individuals and communities have made of it in a plethora of different contexts."68 Recently, Peter Harrison has also questioned the very use of the words "science" and "religion" in generalizations spanning centuries, as these words have had huge transformations in their meanings over time.69

If we focus on the examples in the second set of historical episodes described above (pp. 139–42), it is clear that we will get a very different picture of science and Christianity relations than what is usually conveyed with the first "traditional" set of historical episodes (pp. 134–36). Focusing on the second set will paint a much more positive image of Christianity. However, we do not intend to use this image to propose an "anti-conflict" model, only to provide a corrective to the usual bias and to illustrate that a more complex description should be provided. That is the reason why we cannot accept some of the "apologetic" attempts to deny/minimize the historical debates surrounding the relations of science and Christianity, in particular with thorny issues that, for good or bad reasons, were seen in some historical periods as controversial.

An anti-conflict thesis to advance the cause of Christianity should not be acceptable when bending the historical evidence. This anti-conflict thesis has been justly counted as a myth about science and religion in a recent book.<sup>70</sup> In the past, historians such as Duhem and Jaki, and even Hooykaas, have been criticized for this kind of reasoning. It is true that they emphasized the positive contributions of Christianity to the development of modern science (with some of the historical episodes we noted here in our second set of examples), although it is debatable to what extent their views overstated the limits of both the historical evidence available and sound interpretation.71 This kind of debate goes beyond the scope of this article, but should remain as an important warning.72

Nowadays, historians have moved away from conflict and anti-conflict models<sup>73</sup> to find the complexity of real life, as noted by David C. Lindberg:

Thus the story recounted in this chapter is not one of warfare between science and the church. Nor is it a story of unremitting support and approval. Rather, what we find, as we ought to have suspected, is a relationship exhibiting all of the variety and complexity with which we are familiar in other realms of human endeavor – conflict, compromise, accommodation, dialogue, alienation, the making of common cause and going of separate ways.<sup>74</sup>

We would like to finish by pointing out that although historians have studied intensively in the last century the relations between science and Christianity and most have reached that balanced view, popular media have still to discover these complex interactions. A complete account of science and faith relations must make sense of the peaceful events as well as of the conflicts. It is, we believe, time for a *resetting of the agenda* in the dissemination of the history of science and faith, in particular at popular levels – TV, films, plays, press, educational resources, school textbooks, and others.

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#### Notes

- <sup>1</sup>Thomas H. Huxley, "Darwin on the Origin of Species," Westminster Review, 2nd ser., 17 (1860): 556.
- <sup>2</sup>Ian G. Barbour, *Religion in an Age of Science* (San Francisco, CA: HarperSanFrancisco, 1990), chapter 1.
- <sup>3</sup>Alister McGrath, *Science and Religion: A New Introduction*, 2nd ed. (Malden, MA: Wiley–Blackwell, 2010), 50.

6Ibid., 11.

- <sup>7</sup>A very good historical review of how the conflict model has been dismantled among historians during the twentieth century can be found in the introduction to the book by David C. Lindberg and Ronald L. Numbers, ed., *God and Nature: Historical Essays on the Encounter between Christianity and Science* (Berkeley, CA: University of California Press, 1986). The complexity of such relations was defended with many examples by John H. Brooke, *Science and Religion: Some Historical Perspectives* (Cambridge, UK: Cambridge University Press, 1991). See also endnote 73 below.
- <sup>8</sup>Alister McGrath, "Conflict or Mutual Enrichment? Why Science and Theology Need to Talk to Each Other," *Science and Christian Belief* 27, no. 1 (2015): 7.
  <sup>9</sup>Colin A. Russell, "The Conflict Metaphor and Its Social
- <sup>9</sup>Colin A. Russell, "The Conflict Metaphor and Its Social Origins," *Science and Christian Belief* 1, no. 1 (1989): 3, abstract.

- <sup>11</sup>Ibid., 7.
- <sup>12</sup>John Henry, "Religion and the Scientific Revolution," in *The Cambridge Companion to Science and Religion*, ed. Peter Harrison (Cambridge, UK: Cambridge University Press, 2010), 39.
- <sup>13</sup>From a letter written in 1944 from a Nazi prison cell, Dietrich Bonhoeffer, *Letters and Papers from Prison* (London: SCM Press, 1971), 311.
- <sup>14</sup>Peter Harrison, *The Territories of Science and Religion* (Chicago, IL: The University of Chicago Press, 2015).

<sup>&</sup>lt;sup>4</sup>Ibid., 1.

<sup>5</sup>Ibid.

<sup>&</sup>lt;sup>10</sup>Ibid., 4.

## **Article** *Science and Christianity Conflicts: Real and Contrived*

<sup>15</sup>Peter Harrison, "That Religion Has Typically Impeded the Progress of Science," in *Newton's Apple and Other Myths about Science*, ed. Ronald L. Numbers and Kostas Kampourakis (Cambridge, MA: Harvard University Press, 2015), 195.

<sup>16</sup>A similar strategy has been denounced in the characterization of Enlightenment, in contrast to the seventeenth century, as promoting secularization, because

the methods and conclusions of the natural philosophers were turned against the authority of the established Churches. *With carefully selected examples, this story can be attractive and plausible.* (Our italics)

from John H. Brooke, "Science and Religion," in *The Cambridge History of Science: Volume 4, Eighteenth-Century Science*, ed. Roy Porter (Cambridge, UK: Cambridge University Press, 2003), 741.

<sup>17</sup>For Comte, history could be viewed in three phases: (1) a theological phase with supernatural explanations for natural phenomena, (2) a metaphysical phase with reasoned explanations using abstract ideas, and (3) positive science giving the right explanations based on the scientific method. For more on that, see John H. Brooke, "Science and Secularization," in *The Cambridge Companion to Science and Religion*, ed. Peter Harrison (Cambridge, UK: Cambridge University Press, 2010), 103–23 (in particular, p. 104). A striking example of this approach can be seen in Anthony Wallace, *Religion: An Anthropological View* (New York: Random House, 1966):

The evolutionary future of religion is extinction. Belief in supernatural beings and supernatural forces that affect nature without obeying nature's laws will erode and become only an interesting historical memory ... belief in supernatural powers is doomed to die out, all over the world, as the result of the increasing adequacy and diffusion of scientific knowledge. (p. 265)

<sup>18</sup>David C. Lindberg and Ronald L. Numbers, "Beyond War and Peace: A Reappraisal of the Encounter between Christianity and Science," *Perspectives on Science and Christian Faith* 39, no. 3 (1987): 140. This was a minimally corrected and revised version of a paper previously published in *Church History* 55, no. 3 (1986): 338–54.

<sup>19</sup>Lindberg and Numbers, "Beyond War and Peace," 145. For a recent book with more details, see Ronald L. Numbers, ed., *Galileo Goes to Jail and Other Myths about Science and Religion* (Cambridge, MA: Harvard University Press, 2009).

<sup>20</sup>Duncan Aikman, "Lemaître Follows Two Paths to Truth," *New York Times* (February 19, 1933): 18.

<sup>21</sup>For details on these debates, see Jeffrey Burton Russell, Inventing the Flat Earth: Columbus and Modern Historians (New York: Praeger, 1991); Lesley B. Cormack, "That Medieval Christians Taught That the Earth Was Flat," in Numbers, ed., Galileo Goes to Jail and Other Myths about Science and Religion, 28-34; Pablo de Felipe, "The Antipodeans and Science-Faith Relations: The Rise, Fall and Vindication of Augustine," in Augustine beyond the Book: Intermediality, Transmediality, and Reception, ed. Karla Pollmann and Meredith J. Gill (Leiden, The Netherlands: Brill, 2012), 281-311; Lesley B. Cormack, "That before Columbus, Geographers and Other Educated People Thought the Earth Was Flat," in Newton's Apple and Other Myths about Science, ed. Numbers and Kampourakis, 16-22; Louise M. Bishop, "The Myth of the Flat Earth," in Misconceptions about the Middle Ages, ed. Stephen J. Harris and Bryon L. Grigsby (New York: Routledge, 2008), 97-101.

<sup>22</sup>The most common model, dating back to Crates of Mallus in the second century BC, included the existence of four isolated land-masses, one in each of the quarters of the surface of the spherical earth.

<sup>23</sup>A classical survey of the evolution of views on the shape of the earth and the antipodes can be found in William G. L. Randles, "Classical Models of World Geography and Their Transformation Following the Discovery of America," in The Classical Tradition and the Americas, vol. 1, European Images of the Americas and the Classical Tradition, ed. Wolfgang Haase and Reinhold Meyer (New York: Walter de Gruyter, 1993), 5-76. Reprinted in W.G.L. Randles, Geography, Cartography and Nautical Science in the Renaissance: The Impact of the Great Discoveries (Aldershot, UK: Ashgate, 2000). See also de Felipe, "The Antipodeans and Science-Faith Relations." For a more popular introduction, see \_\_\_\_, "The Modern Myth of the Medieval Flat Earth," in Evangelische Akademie im Rheinland (2017), http://www.theologie-naturwissenschaften .de/startseite/leitartikelarchiv/flat-earth-myth.html, accessed on February 16, 2017.

<sup>24</sup>Stillman Drake, *Galileo: A Very Short Introduction* (Oxford, UK: Oxford University Press, 1980); Ernan McMullin, ed., *The Church and Galileo* (Notre Dame, IN: University of Notre Dame Press, 2005); and Annibale Fantoli, *Galileo: For Copernicanism and for the Church*, 3rd English ed. (Vatican: Vatican Observatory Publications, 2003).

<sup>25</sup>The review was published in July 1860 in *The Quarterly Review*, and contained this telling declaration:

Our readers will not have failed to notice that we have objected to the views with which we are dealing solely on scientific grounds. We have done so from our fixed conviction that it is thus that the truth or falsehood of such arguments should be tried. We have no sympathy with those who object to any facts or alleged facts in nature, or to any inference logically deduced from them, because they believe them to contradict what it appears to them is taught by Revelation. We think that all such objections savour of a timidity which is really inconsistent with a firm and well-intrusted faith.

Quoted in John R. Lucas, "Wilberforce and Huxley: A Legendary Encounter," *The Historical Journal* 22, no. 2 (1979): 318. Darwin's letter to Hooker is quoted by Lucas. For more on the Oxford debate, see Sheridan Gilley, "The Huxley-Wilberforce Debate: A Reconsideration," in *Religion and Humanism*, ed. Keith Robbins (Oxford, UK: Blackwell, 1981), 325–40. See also John H. Brooke, "The Wilberforce-Huxley Debate: Why Did It Happen?," *Science and Christian Belief* 13, no. 2 (2001): 127–41.

<sup>26</sup>Henslow criticized the Christian geologist Sedgwick in defense of Darwin during a public lecture in May 1860:

I got up, as Sedgwick had alluded to me, and stuck up for Darwin as well as I could, refusing to allow that he was guided by any but truthful motives, and declaring that he himself believed he was exalting and not debasing our views of a Creator, in attributing to him a power of imposing laws on the Organic World by which to do his work, as effectually as his laws imposed on the inorganic had done it in the Mineral Kingdom.

I believe I succeeded in diminishing, if not entirely removing, the chances of Darwin's being prejudged by many who take their cue in such cases according to the views of those they suppose may know something of the matter.

Letter from J. S. Henslow to J. D. Hooker, May 10, 1860, published in L. Huxley, Life and Letters of Sir J. D. Hooker,

vol. 1, p. 512, and quoted here from Nora Barlow, ed., *Darwin and Henslow: The Growth of an Idea* (London: Ben-tham-Moxon Trust, 1967).

- <sup>27</sup>Two "classical" studies are James R. Moore, *The Post-Darwinian Controversies: A Study of the Protestant Struggle to Come to Terms with Darwin in Great Britain and Amer-ica, 1870–1900* (Cambridge, UK: Cambridge University Press, 1979); and David N. Livingstone, *Darwin's Forgot-ten Defenders: The Encounter between Evangelical Theology and Evolutionary Thought* (Vancouver, BC: Regent College Publishing, 1984). Many more books and papers have been published on the Christian responses to Darwinism in the nineteenth century, studying specific historical characters and key events. A recent book on the subject is David N. Livingstone, *Dealing with Darwin: Place, Politics, and Rhetoric in Religious Engagements with Evolution* (Baltimore, MD: Johns Hopkins University Press, 2014).
- <sup>28</sup>Darwin's letter to John Fordyce, May 7, 1879, in *Darwin Correspondence Project*, https://www.darwinproject.ac.uk /entry-12041, accessed on February 16, 2017.
- <sup>29</sup>Thomas H. Huxley, "The Interpreters of Genesis and the Interpreters of Nature," in *The Nineteenth Century* 18, no. 106 (1885): 849–60, writes,
  - The antagonism between science and religion, about which we hear so much, appears to me to be purely factitious-fabricated, on the one hand, by short-sighted religious people who confound a certain branch of science, theology, with religion; and, on the other, by equally short-sighted scientific people who forget that science takes for its province only that which is susceptible of clear intellectual comprehension; and that, outside the boundaries of that province, they must be content with imagination, with hope, and with ignorance.

Quoted from the republication in *Science and Hebrew Tradition* (New York: D. Appleton and Company, 1895), 160–61.

- <sup>30</sup>Sigmund Freud, Introductory Lectures on Psycho-Analysis: A Course of Twenty-Eight Lectures Delivered at the University of Vienna, trans. Joan Riviere (London: George Allen and Unwin, 1922), 240–41. Quoted in Dennis R. Danielson, "That Copernicanism Demoted Humans from the Center of the Cosmos," in Numbers, ed., Galileo Goes to Jail and Other Myths about Science and Religion, 50.
- <sup>31</sup> Friedel Weinert dedicated a whole book to this idea, *Copernicus, Darwin & Freud: Revolutions in the History and Philosophy of Science* (Malden, MA: Wiley–Blackwell, 2009). He apparently was unaware of the criticism offered in the references in endnote 34.
- <sup>32</sup>That was the typical medieval cosmology reflected, for example, in Dante's *Divine Comedy*, in the early fourteenth century.
- <sup>33</sup>The title of a book by John Wilkins defending the Copernicanism is very telling: *A Discourse Concerning a New Planet* (London: John Maynard, 1640).
- <sup>34</sup>Danielson, "That Copernicanism Demoted Humans from the Center of the Cosmos," 51. A longer detailed analysis of this topic was offered before by the same author in "The Great Copernican Cliché," *American Journal of Physics* 69, no. 10 (2001): 1029–35. This topic has also been discussed by Michael N. Keas, "That the Copernican Revolution Demoted the Status of the Earth," in *Newton's Apple and Other Myths about Science*, ed. Numbers and Kampourakis, 23–31.
- <sup>35</sup>Geoffrey Cantor and Chris Kenny, "Barbour's Fourfold Way: Problems with his Taxonomy of Science-Religion Relationships," *Zygon* 36, no. 4 (2001): 769.

- <sup>36</sup>Jason M. Rampelt, "Religion as a Cause in Scientific Research," *Annals of Science* 67, no. 1 (2010): 121.
- <sup>37</sup>John H. Evans and Michael S. Evans, "Religion and Science: Beyond the Epistemological Conflict Narrative," *Annual Review of Sociology* 34 (2008): 97.
- <sup>38</sup>Aubrey L. Moore, "The Christian Doctrine of God," in *Lux Mundi*, ed. Charles Gore, 10th ed. (London: John Murray, 1890), 99.
- <sup>39</sup>There were other previous attacks against astrology by the church fathers, such as Hippolytus in the third century with his *The Refutation of All Heresies*.
- <sup>40</sup>The main anti-astrological texts by Augustine are in *Confessions* 7.6,8–10 and the *City of God* 5.1–7. For discussion, see Cristóbal Macías Villalobos, *Ciencia de los Astros y Creencias Astrológicas en el Pensamiento de San Agustín* (Madrid, Spain: Ediciones Clásicas, 2004).
- <sup>41</sup>À particularly problematic situation was the birth of twins of different sex that were conceived at the same time and that were different only by a brief difference in the timing of birth; the timing could not affect the sex that was already determined before birth.
- <sup>42</sup>Origen, "*Commentaria in Genesim*," in *Patrologiæ Græcæ*, ed. Jacques Paul Migne (Paris: J.-P. Migne, 1862), vol. 12, col. 79. On that point, see Stephan Heilen, "(2002–2003): Teaching 'Astrology in Greece and Rome," *The Classical Journal* 98, no. 2 (2002–2003): 201–10 (see footnote 44 and the references within).
- <sup>43</sup>Villalobos, *Ciencia de los Astros y Creencias Astrológicas en el Pensamiento de San Agustín*, 162 (our own translation).
- <sup>44</sup>Thus, although at times Augustine wrote showing an interest in science, he also wrote, in 397, in relation to astronomy:

Knowledge of this kind in itself, although it is not allied with any superstition, is of very little use in the treatment of the Divine Scriptures and even impedes it through fruitless study; and *since it is associated with the most pernicious error of vain prediction* it is more appropriate and virtuous to condemn it.

Augustine, On Christian Doctrine 2.29.46, trans. W. D. Robertson (Indianapolis, IN: Bobbs-Merrill, 1958), 66. Quoted in Albert E. Wingell, "Dante, St Augustine and Astronomy," Quaderni d'italianistica 2, no. 2 (1981): 124 (our italics).

- <sup>45</sup>The film appeared in 2009 and was created and directed by Alejandro Amenábar.
- <sup>46</sup>He even suggested that the different colors in the heavenly bodies were related to different temperatures, as in the terrestrial fires. See Samuel Sambursky, *The Physical World of Late Antiquity* (London: Routledge and Kegan Paul, 1962), 158–60.
- <sup>47</sup>Some of his criticisms of Aristotle are rooted in the ideas of Xenarchus, who was an Aristotelian philosopher himself, and who already criticized the Aristotelian idea of ether in a lost book entitled *Against the Fifth Element*. In some way, the fifth element of Aristotle was continuously challenged in Antiquity by Platonists, Stoics, and Neo-Platonists who held to the fiery nature of the heavens. However, different from Philoponus, they considered the heavenly fires as beings endowed with a soul and as almost divine entities, and so, in the end, all divinized the heavenly bodies. See Sambursky, *The Physical World of Late Antiquity*. <sup>48</sup>Ibid.
- <sup>49</sup>His better-known critic was his contemporary, the Aristotelian philosopher Simplicius, whose name was later used by Galileo in the *Dialogue of the Two Chief Systems of the World* (1632), to represent a foolish follower of Aristotle.

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<sup>50</sup>Photius, *Library* XLIII.

- <sup>51</sup>Philoponus, *De Opificio Mundi* 1.12, quoted in Sambursky, *The Physical World of Late Antiquity*, 151–52.
- <sup>52</sup>Buridan, Quaestiones super octo physicorum libros Aristotelis 4.4, trans. Marshall Clagett, The Science of Mechanics in the Middle Ages (Madison, WI: University of Wisconsin Press, 1959), 536. The topic appeared again at the end of Quaestiones in Aristotelis de Coelo et mundo 2.12, published in Iohannis Buridani, Quaestiones Super Libris Quattuor de Caelo et Mundo, ed. Ernest A. Moody (1942; reprint, New York: Kraus Reprint Co., 1970), 176–81.
- <sup>53</sup>Sambursky, *The Physical World of Late Antiquity*, 174, 175.
   <sup>54</sup>Galileo's Letter to Castielli (December 21, 1613). *The Essential Galileo*, ed. and trans. by Maurice A. Finocchiaro (Indianapolis, IN: Hackett Publishing Company, 2008), 104, 105 (reprinted from *The Galileo Affair: A Documentary History*, trans. and ed. Maurice A. Finocchiaro (Berkeley, CA: University of California Press, 1989). Nearly the same arrangement of words are used in the even more famous Letter to the Grand Duchess Christina (1615):
  - For the Holy Scripture and nature derive equally from the Godhead, the former as the dictation of the Holy Spirit and the latter as the most obedient executrix of God's orders; ... nature is inexorable and immutable, never violates the terms of the laws imposed upon her, and does not care whether or not her recondite reasons and ways of operating are disclosed to human understanding; (p. 116)
- <sup>55</sup>The New Jerusalem Bible (1985). Available online, http:// www.catholic.org/bible/ (accessed on February 16, 2017).
- There are parallels there with this text in Job 28:23–27: God alone understands her path and knows where she
  - [the wisdom] is to be found.
  - (For he sees to the remotest parts of the earth, and observes all that lies under heaven.)
  - When he willed to give weight to the wind and measured out the waters with a gauge,
  - when he imposed a law on the rain and mapped a route for thunderclaps to follow,
  - then he saw and evaluated her, looked her through and through, assessing her.
- <sup>56</sup>Carl F. von Weizsäcker, *The Relevance of Science* (London: Collins, 1964), 120–21.
- <sup>57</sup>Peter Harrison, "The Development of the Concept of Laws of Nature," in *Creation: Law and Probability*, ed. Fraser Watts (Aldershot, UK: Ashgate, 2008), 13 (see also the detailed bibliography in footnote 1 of that paper). See also Peter Harrison, "Laws of Nature, Moral Order, and the Intelligibility of the Cosmos," in *The Astronomy Revolution: 400 Years of Exploring the Cosmos*, ed. Donald G. York, Owen Gingerich, and Shuang-Nan Zhang (Boca Raton, FL: CRC Press, 2012), 375–86 (what seems a draft version of it is available online, http://www.lse .ac.uk/CPNSS/research/concludedResearchProjects/ orderProject/documents/Publications/HarrisonLawsof Nature.pdf, accessed on February 16, 2017).
- <sup>58</sup>A departure point to navigate the immense bibliography on these topics of science and faith in relation with the period of the "Scientific Revolution" can be found in John Henry, "Religion and the Scientific Revolution."
- <sup>59</sup>Charles R. Darwin, On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life (London: John Murray, 1859), ii. The quotes were the following:

But with regard to the material world, we can at least go so far as this – we can perceive that events are brought about not by insulated interpositions of Divine power, exerted in each particular case, but by the establishment of general laws. (William Whewell, *Bridgewater Treatise*)

To conclude, therefore, let no man out of a weak conceit of sobriety, or an ill-applied moderation, think or maintain, that a man can search too far or be too well studied in the book of God's word, or in the book of God's works; divinity or philosophy; but rather let men endeavour an endless progress or proficience in both. (Francis Bacon, *Advancement of Learning*)

In the second edition (1860), a further quotation from Joseph Butler's *Analogy of Religion, Natural and Revealed* was added in between the above two quotations:

- The only distinct meaning of the world "natural" is *stated, fixed,* or *settled;* since what is natural as much requires and presupposes an intelligent agent to render it so, i.e., to effect it continually or at stated times, as what is supernatural or miraculous does to effect it for once.
- <sup>60</sup>William E. Carroll, "Aquinas and Contemporary Cosmology: Creation and Beginnings," *Science and Christian Belief* 24, no. 1 (2012): 5–18.
- <sup>61</sup>Carl F. von Weizsäcker, *The Relevance of Science* (London: Collins, 1964), 152ff.
- <sup>62</sup>G. Lemaître, "La culture catholique et les sciences positives," in Actes du VI<sup>e</sup> congrès catholique de Malines, vol. 5, Culture intellectuelle et sens chrétien (Bruxelles: A.S.B.L., 1936), 65–70. Translated in Pablo de Felipe, Pierre Bourdon, and Eduardo Riaza, "Georges Lemaître's 1936 Lecture on Science and Faith," Science and Christian Belief 27, no. 2 (2015): 179.
- <sup>63</sup>On the interplay of scientific and religious ideas in Lemaître, see Dominique Lambert, *L'itinéraire spirituel de Georges Lemaître* (Bruxelles: Éditions Lessius, 2007) and several chapters in Rodney D. Holder and Simon Mitton, eds., *Georges Lemaître: Life, Science and Legacy* (Berlin/Heidelberg: Springer-Verlag, 2012).
- <sup>64</sup>Key works to popularize the "conflict model" were the following well-known books: John William Draper, *History of the Conflict Between Religion and Science* (1874); John Tyndall, *Address Delivered before the British Association Assembled at Belfast* (1874); Andrew Dickson White, *The Warfare of Science* (1876); and \_\_\_\_\_ A *History of the Warfare of Science with Theology in Christendom* (1896). Their portrait of the historical science and Christianity relationship fits not only the simple conflict model, but also the conflict-retreat model. For more details on this history, see Colin A. Russell, "The Conflict Metaphor and its Social Origins."
- <sup>65</sup>"Science and Religion," Boston Cultivator 7 (1845): 344. Quoted by Ronald L. Numbers, "Introduction," in Galileo Goes to Jail and Other Myths about Science and Religion, 4.
- <sup>66</sup>John H. Brooke, "Science and Religion," in *The Cambridge History of Science: Volume 4, Eighteenth-Century Science*, ed. Porter, 739–61.
- <sup>67</sup>Ibid., 746.
- <sup>68</sup>John H. Brooke, *Science and Religion: Some Historical Perspectives*, 321 [Canto Classics edition, 438].
- <sup>69</sup>See Harrison, The Territories of Science and Religion.
- <sup>70</sup>Noah J. Efron, "That Christianity Gave Birth to Modern Science," in Ronald Numbers, *Galileo Goes to Jail and Other Myths about Science and Religion*, 79–89.
- <sup>71</sup>A direct criticism of Jaki's and Hooykaas's historical views on the major influence of Christianity over the development of modern science appeared in the introduction and some chapters of the book by Lindberg and Numbers, ed.,

God and Nature: Historical Essays on the Encounter between Christianity and Science. An even harsher criticism of Jaki's views can be found in David C. Lindberg's review of Jaki's 1988 book, The Savior of Science, in Isis 81, no. 3 (1990): 538-39. Regarding Hooykaas, it is fair to say that the criticisms he received were mainly for his Religion and the Rise of Modern Science (1972) that has been labeled as an apologetic in favor of Protestantism (in particular, taking into account that he was Protestant himself). See, for example, the fierce review of this book by Lindberg in *Journal of the American Scientific Affiliation* 26, no. 4 (1974): 176-78. Also see the later exchange of letters between D. M. MacKay and Lindberg in Journal of the American Scientific Affiliation 27, no. 3 (1975): 141 and in vol. 28, no. 1 (1976): 48. However, these criticisms do not mention his work emphasizing the role of Portuguese seafarers in the rise of modern science a century before the Reformation: Reijer Hooykaas, "The Portuguese Discoveries and the Rise of Modern Science," Boletim da Academia Internacional da Cultura Portuguesa 2 (1966): 87–107; \_\_\_\_, Science in Manueline Style (Coimbra, Portugal: Academia Internacional da Cultura Portuguesa, 1980); and \_\_\_\_, "The Rise of Modern Science: When and Why?," *The British Journal for the History of Science* 20, no. 4 (1987): 453–73.

<sup>72</sup>An early discussion of the "apologetic" use of the history of science to foster Christianity can be found in Rolf Gruner, "Science, Nature, and Christianity," *Jour-*

nal of Theological Studies 26, no. 1 (1975): 55–81. See other discussions and criticisms of that apologetic approach in John H. Brooke, "HISTORY: The Rise of Science," in *Perspectives, Christian Academic Network*: http://www .christianacademicnetwork.net/newjoomla/index.php /perspectives/a-i/history/the-rise-of-science, accessed on February 16, 2017. Edward B. Davis, "Christianity and Early Modern Science: Beyond War and Peace?," *Perspectives on Science and Christian Faith* 46, no. 2 (1994): 133–35. Willem B. Drees, "Worldly Interests: Apologetics, Authority and Comfort," in *Religion and Science in Context: A Guide to the Debates* (London: Routledge, 2009), 11–38.

- <sup>73</sup>A historical overview of how the conflict thesis has been undermined during the last fifty years has been written recently by John H. Brooke, "Historians," in *The Idea That Wouldn't Die. The Warfare between Science and Religion: Historical and Sociological Perspectives*, ed. Jeff Hardin, Ronald L. Numbers, and Ronald A. Binzley (Baltimore, MD: Johns Hopkins University Press, in press). Special thanks to Prof. Brooke for this reference.
- <sup>74</sup>David C. Lindberg, "The Fate of Science in Patristic and Medieval Christendom," in Peter Harrison, ed., in *The Cambridge Companion to Science and Religion*, 34.

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## **Article**

## Order from Chaos

Scott Bonham

Behold, I am making all things new (Revelation 21:5).

Emergent transitions provide a conceptual framework to relate cosmic history, Genesis accounts, and redemption. In this framework, each new level of emergence is initially in a state of non-order (chaos) and undergoes a transition into a more ordered state; disorder results if there are competing, incommensurate domains. Cosmic history, from quarks to galaxies and from simple cellular life to complex societies, is easily described in this framework. A similar model of God's creative activity, involving states of order, non-order, and disorder, has been elaborated by John Walton based on his analysis of the Genesis accounts in their original cultural setting. With similar models emerging from different perspectives, scripture and science seem to point toward the same underlying truth about God's creative activity. Furthermore, redemptive history from Adam to Christ to the end times can also fit into this conceptual framework, suggesting that this framework reflects important aspects of the way God interacts with the world.

n Passover Friday nearly two thousand years ago, a man died on a cross amidst the chaos and disorder of soldiers, mockers, spectators, and others. In the midst of that chaos and disorder, many believe, a new order came into being. Certainly the religious movement that came out of Jesus's death has had a significant, enduring impact on human history. The central claims of Christian faith go much further, asserting that the life, death, and resurrection of Christ brought into being a new order, a new reality that changes the relationship of God with people, between different groups of people, between the physical and the spiritual, between life and death.

How does this relate to the other great work of God, that of creation? In the prologue of his gospel, John affirms that they are closely related through the person of Jesus Christ.<sup>1</sup> However, creation and redemption are sometimes described as being very different types of events. Wolters, for example, divides redemptive history into three different stages: Creation, Fall, and Redemption.<sup>2</sup> This type of thinking has deep roots; Augustine asserts that the first parents lived in Paradise "where neither death

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nor ill-health was feared, and where nothing was wanting which a good will could desire, and nothing present which could interrupt man's mental or bodily enjoyment,"<sup>3</sup> but that perfect state was lost due to humans' sin.

While frameworks that describe creation and redemption as distinct stages have their strengths, for example, emphasizing the seriousness of sin, a concern is that they can lead to viewing Christ's life, death, and resurrection as something entirely distinct from God's creative activity, and perhaps even seeing Christ's sacrifice as a "plan B" that would not have been necessary if the first man and woman had not sinned. The idea that God might have had to resort to a "plan B," creates, of course, tension with the classical understanding of God having perfect

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wisdom, foresight, and power to bring about his will. The view that God's interaction with the world can be divided into distinct stages also creates tension with the scientific view of cosmic and Earth history in which there are no sharp discontinuities but rather a continuity of different processes – many of which are still present today – shaping the development of the cosmos, Earth, and life. In this article, I present a conceptual framework for understanding both God's creative and redemptive activity that helps to resolve those tensions, rooted in both scientific and scriptural understanding: nucleation and growth of order in an emergent transition.

Throughout scripture, God is portrayed as establishing good order and instructing his people to do the same. Genesis 1 describes God creating in an orderly fashion and calling it "good." God instructed the Israelites through the Law to live orderly lives. The Corinthians were instructed to maintain order in their devotional meetings.4 The association of order and goodness is a central theme of this article, but I first need to clarify how those words will be used. In the rest of this article, the meaning of "goodness" will follow that of the Old Testament scholar John Walton who argues that "good" in the creation account refers to "functioning properly," and not to a moral or ethical statement.5 Thus, "goodness" depends on the context in which it is evaluated, and what is good in one context can be not good in another. For example, at the single-cell organism level, a streptococcal bacterium living in my throat can be perfectly "good," that is, it functions well, takes in nutrients, expels waste, and multiplies. However, at the multicellular organism level (myself), it is not good, as the strep throat infection it causes severely interferes with my proper functioning.

Walton also argues that the main focus of the description of God's creative work in Genesis 1 is best understood as bringing into existence functional order rather than material objects.<sup>6</sup> Related to this, the idea of "order" that I will develop has to do with the proper arrangement of component parts into a system in which new properties and functionalities emerge, expanding a concept coming from phase transitions in materials. The central thesis is that cosmic and redemptive history can be understood as a long series of God bringing into existence additional levels of order to existing reality. First, I would like to illustrate and develop more fully this framework in the context of transitions in the order of materials.

## Order and Disorder in Materials

Diamond and graphite are composed of exactly the same thing-carbon atoms-yet have vastly different properties. One is a hard, clear, highly refractive, large-bandgap semiconductor, while the other is a soft, opaque, strongly absorptive, electric conductor. The difference is not in what they are made of, nor in the particulars of their histories, but in how the atoms are arranged in each solid. Likewise, the different properties of ice, water, and steam arise from the differences in how the atoms are organized. A basic principle in the study of materials is that the electrical, magnetic, thermal, optical, and mechanical properties of materials depend significantly on the order-or lack of order-of the atoms that make them up. Thus, these properties are emergent-they are not properties of individual atoms, but rather arise from how the atoms are ordered. However, that order does affect the individual components: the electronic bonds of a carbon atom in graphite are oriented differently from those in diamond because of the different contexts - graphite order or diamond order-in which the carbon atom finds itself.

The different ways things are or are not ordered correspond to different phases of the material. Ice, water, and steam are different phases of H<sub>2</sub>O; graphite and diamond are different phases of carbon. The concept of phases and their associated order is far more general than atomic arrangements, though. At low temperatures, iron is ferromagnetic while at high temperatures it loses that magnetic property. The liquid crystals that are the heart of LCD displays have different phases, and the application of an electric field changes the ordering of the molecules. Other examples of phases include plasmas (such as in the sun where electrons are stripped out of atoms), superconductivity (where electrons move without resistance), and superfluidity in ultra-cold helium (where the atoms flow without resistance, even uphill). Naturally, the transition of a material from one phase to another - a phase transition - is a significant phenomenon, and has been an area of much study for many years.7

A striking fact about phase transitions is that despite different underlying physics, they have surprisingly similar behaviors. Ferromagnetism in iron comes from the alignment of the intrinsic magnetic moments of the atoms. Superconductivity arises from electrons being paired up due to lattice vibrations. Superfluidity in helium comes from the atoms falling into the same quantum mechanical state. Water freezes at the surface of ice by the electrically polarized molecules attracting each other. Plasmas become normal gas by electrons combining with nuclei to form neutral atoms. Yet all of these are continuous phase transitions; the measure of the amount of order in the system follows a power-law mathematical relationship independent of the specific physical mechanism of the phase transition.8 This power-law behavior cannot be explained through a reductionist analysis of the components themselves or the specifics of their interactions, but rather requires a more holistic description of their cooperative behaviors. Phase transitions are examples of the emergence of general patterns, structures, and behaviors in quite different contexts.

In a phase transition, one can identify three different possible conditions that will be referred to as nonorder, order, and disorder for the purposes of this article. At temperatures above the transition point, the magnetic moments in iron fluctuate randomly in all directions with no relationship to each other; this is a state of non-order. As the material cools below a critical temperature, groups of atoms start aligning their magnetic moments with those around them, and this grows as more atoms join in. Now, there is not necessarily any intrinsic reason that one particular direction is selected for the moments to align, but once order is established, that one direction becomes the preferred direction (referred to as symmetry breaking, because all directions are no longer equivalent), and the rest align with it.

A fully magnetized piece of iron is an example of an ordered state. However, most pieces of iron one encounters do not behave like magnets, though the reason is different from the high temperature stage. At the microscopic scale, all the atoms in a region are ordered with their moments aligned. However, there are different regions or domains in the material with different magnetic orientation directions, which when all added together, cancel each other out. Here *disorder* refers not to a complete lack of order, but rather the condition of multiple domains with some degree of local order but in conflict with each other so that no large-scale order is present.

To summarize, there are three conditions that can exist. *Non-order* refers to the complete lack of any of the particular order, for example, a lack of either local or larger-scale magnetic ordering. *Order* refers

to the material sharing a single ordering orientation, and *disorder* refers to a state in which there are domains of local order that are in conflict with others to negate any long-range order. Note that the terms are being used here differently from how they are often used in the study of phase transitions, in which what I define as "non-order" is more commonly referred to as "disorder," and what I refer to as "order" and "disorder" represent the two ends of a continuum, which might instead be described by the size of the ordered domains. I adopt this terminology for two reasons. First, ambiguity exists in the scientific use of the term "disorder." In the study of phase transitions, "disorder" refers to the unordered phase above the transition temperature. In other areas of condensed matter physics, the term can refer to a lack of long-range order existing below the transition temperature. Second, this usage is parallel to the terminology that Walton adopts, facilitating making connections between science and scripture.

While in some practical applications disorder may not matter or even be desirable, in others it can create significant problems. Disorder exists in both the crystalline atomic structure and magnetic domains of a cast iron skillet; the former has no impact on its ability to cook eggs and the latter keeps it from sticking magnetically to other objects in the kitchen. However, in other applications problems arise from the existence of multiple domains, in particular, the boundaries between them where atoms are caught between two incompatible orientations. This condition generally arises when there are multiple places in the material where order begins, each place independent of the other, called nucleation sites. Silicon chip manufacturers use specially prepared silicon wafers cut from a single crystal chunk, grown from a small single crystal that serves as the nucleation site in the manufacturing process. They do this because the boundaries between different domains of crystalline order would introduce electronic defects that would significantly degrade the performance of the microelectronics. Metal parts in a high performance engine can develop fatigue where microscopic cracks appear and grow until the part fails; these cracks usually start at the boundaries between domains arising from multiple nucleation sites, since the boundaries are weaker than the ordered areas within the domains. It is possible (though quite expensive) to eliminate this by casting pieces as single crystals. The secret is to establish order in a single location or nucleation site that is allowed to grow out to the rest

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of the piece while preventing other nucleation sites from beginning.

The concepts of phase transitions and symmetry breaking are not limited to materials. In particle physics, similarities between the different families of quarks and leptons have long been observed, though they have quite different masses. This led to the formulation of a theory of symmetry breaking between them due to some acquiring excessive mass; in addition, this theory predicted the existence of the Higgs boson, evidence for which is accumulating.<sup>9</sup> Other important phase transitions involving fundamental physics include the separation of the four fundamental forces and the formation of hadrons (e.g., protons and neutrons) from quarks, which are believed to have occurred in the early stages of the universe's existence.<sup>10</sup>

## Structure and History of the Cosmos

The concepts of phase transitions and emergence arising in different fields of physics and related disciplines can be generalized into a conceptual framework describing transitions with emergent properties. This section shows how such a framework of emergent transitions can be used to describe the structure and history of the cosmos, suggesting that such emergent transitions may be a fundamental element of God's creative activity. It also offers an alternative to a reductionist approach to understanding nature that seems to leave no place for divine activity. This follows emergence theory that has been developed elsewhere<sup>11</sup> and uses the language of transitions to describe it. First a synchronic and then a diachronic description will be offered.

We observe synchronic emergence when, at any given point in time, the properties of an entity may be dependent on, but qualitatively different from, its components. Subatomic particles such as neutrons, protons, and electrons combine in different ways to form different atoms that have properties different from their parts and different from each other. Atoms, in turn, assemble to form molecules, which can be small and behave as gases, be large and flexible, or form ridged arrays in crystals. Certain molecules such as amino acids can further be strung together to form long chains to make more complex molecules that can serve many different functions. These might function as digestive enzymes, molecular pumps to maintain the right level of ions in a cell, or structures that build other proteins from DNA strands. While these molecules have interesting properties in their own right, when assembled in just the right way relative to each other, they form living cells that are able to take in nourishment, repair themselves, and reproduce-alive in a way that the constituent parts are not. Each macroscopic living organism is composed of vast numbers of these cells that function together as a tree, a butterfly, or a dog. At the next level, different living organisms form complex, interrelated ecosystems. As we move up from the parts of atoms to vast ecosystems, we see multiple layers of order and new properties emerging out of the structures below them, dependent on, but qualitatively different from, their constituent parts.

The emergence of order from non-order is a feature not only of the different scales of natural phenomena, but also of natural history in a diachronic description. Current theories of the big bang posit that the earliest stage of the universe was "quark soup" in which the tremendous heat and density meant that even subatomic particles such as protons and neutrons did not exist. As the universe expanded and cooled down, a phase transition took place in which quarks organized themselves into stable protons and neutrons. This drastically changed the nature of the material universe into one dominated by electromagnetic forces rather than by strong nuclear reactions between its components.

After further cooling, another important phase transition took place as neutral atoms were able to form. This led to the matter in the universe becoming "invisible" to photons in the universe at that time; these photons which no longer constantly interact with matter persist today as the cosmic microwave background. This phase transition again drastically changed the properties of the matter in the universe, which at that time was fairly evenly spread throughout it, to a condition in which the interactions were dominated by gravity. Gravitational interactions eventually caused slightly denser spots of gas to condense into clouds of gas, which in turn strengthened the gravitational attraction until they condensed into stars and galaxies, adding another level of order to the universe.

The formation of stars can be thought of in terms of another critical phase transition with the emergence of completely new properties. Not only did fusion of atomic nuclei begin inside stars that caused them to radiate electromagnetic energy, but the resulting radiation pressure pushed away the gas not yet incorporated into the star out of its vicinity, leading to dense, relatively well-defined bodies surrounded by nearly empty space. These stars also became factories for heavier atomic nuclei; the larger of them would eventually blow much of this material into surrounding space, where it could be incorporated into second-generation stellar systems like the one we live in. Gravitational attraction caused large quantities of the dust incorporating heavier elements such as carbon, silicon, and iron to condense into solid chunks and eventually into rocky planets like ours, which remained in place even after the solar radiation had cleared much of the gas out of the inner solar system.

The initial non-order of our planet formed by rocks and dust colliding and mixing up began to be ordered. Much iron and nickel, along with many heavy radioactive materials, sank down to form the earth's magnetic core (which in turn protects us from solar bombardment), silicon, and other elements that form much of the rock in the earth's crust, and gases and water vapor above it. Earth's once-molten surface cooled to form a solid surface, and eventually cooled enough that liquid water could form on it, allowing the emergence of important properties of our planet that are crucial for life. In this liquid water, different atoms somehow became ordered into complex molecules which began to cooperate with each other as the first primitive life emerged. This transition eventually led to "reshaping" the earth, including an oxygen-rich atmosphere and the organizing of multicellular creatures.

Once again, this transition produced a layer of order with qualitatively new properties and forms, which spread out from the shallow seas to inhabit almost every part of the earth's surface. One line developed increasingly complex nervous systems, and one of those species developed the ability to use tools, make long-term plans, and work in complex organizations – yet another emergent, ordering transition with new properties. From quarks to protons to atoms, from gas to galaxies and stars, from a molten ball to core and mantle to current geological structures, from complex molecules to single cell life, from multicellular organisms to human beings in complex societies, history is full of new levels of order emerging. Each order emerges out of preexisting ones, dependent upon them but possessing properties and structures distinct from those which exist in the lower level.

Another important aspect of this framework of emergent transitions is that it can provide a counterbalance to the tendency for reductionist scientific approaches to understanding the cosmos, in which there seems to be no place for God's creative activity. In the reductionist approach, phenomena are understood in terms of their underlying components and material processes that brought them into existence. Clearly, the components of material entities will themselves be material entities, and material processes will involve material entities. Thus, about the only way that reductionist science could point to God would be through its failure to explain something-the "God of the gaps" approach-which is fraught with difficulties. However, an organizational or systems approach to understanding the world around us does not intrinsically exclude nonmaterial entities such as God. It could describe organizational structures that include both material and nonmaterial entities, as well as organizational structures with properties that do not come directly from the components, such as the phase transitions described earlier. This idea of emergent transitions illustrates such an organizational structure.

Further, an emergent as opposed to reductionist conceptual framework provides a different way of thinking about the seeming improbability of a world in which intelligent life can exist. Despite the great number of emergent transitions around us-present and past-the entities in the underlying layer must possess certain characteristics and/or histories for the next level of order to emerge. The incredible fine tuning of the universe, in which slight deviations in the initial speed of the expansion of the universe, the relative masses of the fundamental particles, the relative strengths of the different forces, and many more aspects, has been explored by both non-Christian and Christian authors.<sup>12</sup> Many characteristics of our earth, such as its distance from the sun, its size, magnetic field, amount of water, a single large moon, et cetera, have been critical to its supporting of life. Exactly how complex molecules formed and began to cooperate in the first living cells is still an open scientific question. While genetic mutation and natural selection do provide a plausible explanation for the variety of life forms, it has been argued that

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it is quite improbable that all the diversity we see has arisen strictly from unguided, random genetic variation.<sup>13</sup> When viewed through a reductionist, materialist framework, it is hard to provide an explanation for what appears to be improbability piled upon improbability, and some are inclined to reintroduce God as an efficient or scientific cause.<sup>14</sup> However, in the more holistic, functional framework of emergent transitions, there is a general pattern in the structure and history of the cosmos of new layers of order emerging on top of older ones, from quarks to galaxies and from big bang to human civilization, suggesting that this pattern reflects something intrinsic about the functional design of the universe.

## Non-order, Order, and Disorder in Genesis

In the ancient Near East, a common motif in creation accounts described the gods as bringing order and functionality to preexisting, non-ordered and nonfunctional material. They do not create perfect order out of nothing. Following a tradition that stretches back to some of the early church fathers<sup>15</sup> and gained strength with the discovery of ancient Middle Eastern creation texts,<sup>16</sup> John Walton argues that the creation accounts in Genesis should be understood in that context, that its focus is on the functional rather than the material origins of the world. This would be consistent with the idea that what Genesis and the rest of scripture describe are the establishment of yet another layer of order on top of the physical and biological orders as now studied by science-some sort of spiritual or human-divine structure.

It should be noted that Walton seeks not to reinterpret Genesis through modern cultural understandings, neither to accommodate modern scientific accounts,<sup>17</sup> nor to employ the hermeneutic of skepticism.<sup>18</sup> Neither is he modifying or defending "traditional" readings of Genesis, such as six twenty-four hour days, which have their intellectual roots in nineteenth-century American cultural understanding, drawing from Scottish common-sense philosophy and Baconian understanding of science.19 Instead, drawing upon scholarship in archeology, anthropology, communication theory, and other related fields, Walton is trying to reconstruct, as much as possible, the original meaning of the text in its initial cultural context as would have been given to and understood by the Hebrew community that produced it. In the rest of this section, I will present a summary of the model based on relevant sections of his works, *The Lost World of Genesis One, The Lost World of Adam and Eve,* and (with co-author Brent Sandy) *The Lost World of Scripture.* I will not attempt to lay out the arguments for his conclusions, which can be found in those works, but simply summarize Walton's positions.

The accounts in Genesis were produced in a very different cultural context than modern western thought. It was an oral culture in which communities transmitted and preserved knowledge that may have originated from an authority such as Moses; the knowledge was recorded in writing at some later time. In an oral tradition, the core message is defended from change while allowing some flexibility in the details. The text is interwoven with the community's identity and purpose and is not critically assessed in the same manner as is common in written cultures.<sup>20</sup> Scientific, theological, and historical analysis as we now know them had not yet been developed.<sup>21</sup> These cultures made no distinction between "natural" and "supernatural" phenomena, and symbolism was quite important. The cultures of the ancient Near East also were not very interested in the material origins of the cosmos (where did all the stuff come from?), but rather, in the functional origins (from where did the order and functionality of the world, civilization, etc. come from?).<sup>22</sup>

The accounts in Genesis focus on God's bringing functional, productive order to nonfunctional, unproductive chaos, and not on the material process of the cosmos coming into being that our culture tends to emphasize. This does not contradict the doctrine that God brought material things into existence out of nothing; rather, the focus of the text is the creation of functional order and not the creation of matter.23 The darkness and deep waters in Genesis 1 and the arid land in Genesis 2 were common motifs in ancient creation stories representing nonfunctional chaos, and would have been understood to exist before God began the creative work described in the passages. Note that the darkness and the seas are not called "good" in Genesis 1, and they no longer exist in the new creation described in Revelation 20. Days one and four in Genesis 1 do not actually refer to the creation of light, the sun, moon, and stars as material entities, but rather the ordering of time into days, months, seasons, and years. The rest of God on day seven, which Walton argues is the climax of the passage, does not represent that God had

fully completed his creative work, but rather that he was taking up residence in his temple (the world) and commencing ordinary rule from it.<sup>24</sup>

God's rest on day seven in which he commences ordinary rule immediately follows the creation of human beings, who bear his image and are charged to rule over the earth. Bearing God's image involves both having some of God's characteristics-for example, the ability to bring order to non-order-and being his representatives. Thus, human beings were created to join God and be his agents in continuing to bring order from non-order to the world. Human beings also were given a priestly role in representing the world to God and God to the world. In addition to the temple motifs Walton sees in Genesis 1, he associates the garden in Genesis 2 with gardens that were often part of ancient temple complexes and suggests that the man and woman may not have lived there continuously, but rather entered into that sacred space to meet with God.25

While Walton believes the man and woman described in Genesis 2-3 were actual historical figures, he argues their significance is as archetypes representing humanity. They are not necessarily the biological ancestors of the entire human race, but were given a particular priestly role. To use terminology introduced above, they were selected to be the nucleation site of a new human-divine order, which presumably was to have been spread to the rest of the human race through them. The trees named in the garden represented that which is God's to give-wisdom and life. The man and woman did not possess intrinsic immortality, but had the opportunity to live forever by partaking of God's provision through the tree of life. True wisdom is achieved in obedience to God, not seeking it on one's own terms. The disobedience of the man and woman in seeking to achieve wisdom outside of God's will introduced disorder into the world. Disorder results when humans seek to set up an order organized around themselves and their desires, rather than an order centered on God and his plan. The first consequence of disobedience was a broken relationship with God and his special provision. The man and woman did not become mortal as a consequence of disobedience, but lost access to the remedy for their mortality. Similarly for the earth and the rest of creation-the disobedience of Adam and Eve did not introduce chaos or evil into creation, but interfered with God's plan to bring good order to it through human activity.26

#### Discussion

The convergence of Walton's interpretation of the Genesis passages and the framework of emergent transitions helps address multiple sources of tension between scripture and the understanding of the natural-scientific history of the cosmos and life on Earth. First, if the focus of the Genesis text is the creation of functional order rather than of material entities, then its description of God's creative work operates at a different and complementary level than that coming out of natural science. This is similar to the statement that a particular shoe is made by Nike; it is true at the functional level-the Nike company planned, designed, and marketed it-but not true at the material level. Since Nike contracts out all its manufacturing, the people who assembled the shoe are actually employed by some other company.

One example of how this functional perspective can resolve tensions is shown in the resolution of the conundrum of how one can have light on day one before the sun comes into being in day four. First, if God's activity on days one and four is not the physical creation of day, night, sun, moon, and stars, but is meant to establish their function for humans reckoning the passage of time and cycles of life, then there is no contradiction with our knowledge that one cannot have light without a source. Second, and closely related, if the texts in Genesis are about the establishment of functional order for image-bearing humans, then much of cosmic history understood through natural science-for example, the big bang, formation of the earth, emergence of many different forms of life-takes place well before the account in Genesis 1 picks up in verse 3. Stars and galaxies, oceans and mountains, animals and fish already existed by Genesis 1:2; the rest of the passage is about God establishing their functional roles for human existence. Third, if "good" is understood to refer to being functional and productive within a system, then as in the previous example of a streptococcal bacterium, something can be good at one level and not good at another. Thus, we can describe biological death of organisms as "good," necessary for proper functioning at an ecosystem level, but not being good in the new creation previewed at the end of Revelation and other scriptures. Order at one level does not automatically translate into order at a subsequent level; it can translate into non-order that then needs to undergo a transition to establish order.

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A particular application of this insight opens up possibilities for how to understand the Fall in relationship to scientific understandings of cosmic history, for which multiple approaches have been proposed.27 One set of approaches maintains that human sin is the cause of evil and chaos, though with a variety of different ideas about exactly what was the direct consequence of human sin, ranging from drastic changes in the fundamental laws of physics, to physical death of humans, to merely altering human psychological and spiritual state. Another set of approaches reconsiders whether human sin is the temporal cause of natural evil, instead suggesting there might be retroactive causation, nontemporal causation, or a gradual development in human understanding of sin and its consequences over time. All of these proposed explanations have both their strengths and their weaknesses. While there are major differences between them, these different approaches are largely operating out of a two-category paradigm, in which different entities and aspects of creation are considered as belonging either to the category of that which is good, ordered, and within the divine will, or to the category of that which is evil, chaotic, disordered, sinful, and in opposition to God. They differ primarily in what is assigned to each category and how the latter category comes about.

The three-category paradigm proposed by Walton allows there to be things, for example, biological death, that are not good but also are not a result of human sin that tries to set up self-centered order in opposition to God.<sup>28</sup> Thus we could accept Arthur Peacocke's argument that suffering and death are intrinsic to the process through which self-aware beings possessing free will came to be,<sup>29</sup> but, at the same time, we can agree with Paul that death is the enemy.<sup>30</sup> Rather than being the cause of suffering, death, and natural evils, human sin interfered with God's plan to fully bring forth the order hinted at in the Garden of Eden and described at the end of Revelation. If, as argued above, humans were created to be the primary agents for establishing God's good order on the earth, then human rebellion has consequences for the rest of creation in what we have failed to do:

For the creation waits with eager longing for the revealing of the sons of God. For the creation was subjected to futility, not willingly, but because of him who subjected it, in hope that the creation itself will be set free from its bondage to corruption and obtain the freedom of the glory of the children of God. For we know that the whole creation has been groaning together in the pains of childbirth until now. And not only the creation, but we ourselves, who have the first fruits of the Spirit, groan inwardly as we wait eagerly for adoption as sons, the redemption of our bodies.<sup>31</sup>

God commanded humans bearing his image to fill and subdue the earth,<sup>32</sup> and made Adam and Eve to work and care for the garden.33 These are both consistent with an idea that humans were not to do their own thing or to lie around the garden in ease, but rather to work in expanding the garden until the sacred order nucleated in Eden filled the earth, resulting in something like what is pictured at the end of Revelation where God is intimately present with humans, who also have access to the tree of life. Thus humans have a pivotal role as created sub- or cocreators in helping to shape the final outcome,<sup>34</sup> but operating firmly underneath the authority of God. Along with death, things such as sickness and natural disasters could be understood to be in the category of things that are not-good but are also not the result of sin, things which are part of a lower order and still need to be addressed in the establishment of the higher one. The same meteorological system that produces summer rainstorms to water prairies and crops in the Midwest also gives rise to tornados.

The framework of an emergent transition could also be extended to characterize key points in the history of God's interaction with humans. God's choosing and forming a covenant with Adam and Eve, with Noah, with Abraham, with the nation of Israel through Moses, with David, and with others throughout Old Testament history can be thought of in terms of God's seeking to nucleate an emergent transition into a new human-divine order. Furthermore, a number of tensions between scripture and history/ science disappear if we understand their significance to be that of nucleation sites for divine order rather than biological ancestry. Eve becomes the mother of all the living, and sin and death entered into the world through Adam, not necessarily as our biological ancestors but as flawed nucleation sites. In the same sense, we are the children of Noah, even if the flood was a local one in Mesopotamia, and Abraham really is the father of all who believe. We are heirs of the Mosaic covenant and, through conforming to God's order, we have been grafted onto it.

Of course, the most important of these nucleation sites for God's emergent order is the life, death, and

resurrection of Christ. Metaphors such as a kingdom, a body, and a building all reflect an ordered system in which the whole is more than a collection of parts. Statements that Jesus's disciples would be known by their love one for another reinforce that it is out of the collective relationships that new phenomena emerge. Jesus's parables of mustard seed and the yeast, and the growth of the church from a small band of disciples to a worldwide movement, parallel the nucleation and growth of an ordered phase in materials. Exhortations to leave an old way of life, to be conformed to the likeness of Christ, reflect changes in the orientation of the constituent parts as they become part of the new order. The understanding of sin and opposition to God overlaps comfortably with the idea that humans introduce disorder when they seek to build order centered on their own selves rather than on God. Discussions about eternal life and a new creation, as well as the mysterious features of the resurrected Christ (for example, entering into locked rooms) point toward entirely new phenomena emerging in the new order, of which we currently have glimpses only. Note that Jesus explicitly stated that he was not overthrowing the Mosaic order, but rather he was fulfilling and adding to it. Just as helium-3 undergoes multiple transitions from a gas to a liquid to a superfluid, biblical history can be thought of as passing through multiple transitions from the beginning to God's final kingdom.

This general framework of emergent transitions is useful as a framework to understand the sweep of both cosmic and divine history. It suggests something about metaphysical reality, something about God's general approach to his interactions with our world. This leads to six additional congruences with doctrines about God, the world, and applications to our lives.

- 1. The general pattern of emergent transitions across the sweep of history is consistent with an unchanging divine nature.
- 2. The pattern emphasizes that scriptural history is a progression from a starting point in a garden to an end point in a city, and is not trying to return to an original perfect state. Thus Christ's life, death, and resurrection were not simply about counteracting the effects of the first sin, but fully and finally ushering in a new order that was not originally present.
- 3. As emergent phenomena come not from individual parts but their collective interactions, the

pattern emphasizes the relational elements of God's plan. The God of scripture is a covenantmaking God. The Law is fulfilled by loving God and one's neighbor. Christians are described as members of a body and of a building.

- 4. The pattern is compatible with several major models of the salvific efficacy of Christ's life, death, and resurrection. Christ, as the model human whom we should imitate, resonates with the image of atoms rearranging themselves to conform to a new order. Christ, as the sacrificial lamb who turns away God's wrath, incorporates the concepts of the Mosaic order, yet builds on them to make something new. Christ's triumph over sin and death reflects an emergence of an entirely new phenomenon.
- 5. The pattern reinforces the central role of Christ and our need to be in relationship with him and conformed to his pattern. At the same time, it also affirms that much of the present reality – for example, physical, social, economic – will not disappear but will be incorporated into the emergent reality; the glory and honor of the nations will be brought into the kingdom.<sup>34</sup>
- 6. The pattern has obvious applications to evangelism and missiology. People generally come into relationship with Christ through other people instead of through direct divine action; and effective mission strategies often focus on establishing a nucleus of believers in the target group and enabling the gospel to spread out from it.

As with any framework we use to describe the reality in which we find ourselves, it makes simplifications which, if taken to the extreme and not balanced with other information and models, can introduce distortions. For one, the focus on emergent order could tend to minimize sin, evil, human responsibility, and judgment, which are major themes in scripture. Two, this framework tends to minimize significant differences found in frameworks that draw distinct stages in scriptural history. Three, it is a broad analogy to compare atoms arranging themselves in a material to establishment of an order in which God himself plays a significant role.

The framework of emergent transitions has some limitations and does not replace other theological frameworks. However, it is a productive framework that can be used to describe a wide range of phenomena, from early stages of the universe to emergence

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of life to God's work in Genesis to his establishment of covenants with his people. The way that it can productively describe multiple levels of God's interactions with the world suggests that the framework captures key aspects of the reality of God's relationship with the world and thus is a valuable tool for understanding it.

#### Notes

- <sup>1</sup>John 1:1–18. <sup>2</sup>Albert M. Wolters, *Creation Regained: Biblical Basics for a Reformational Worldview*, 2nd ed. (Grand Rapids, MI: Eerdmans, 2005).
- <sup>3</sup>Augustine, *The City of God*, trans. Marcus Dods (New York: Random House, 1950), 14.10.

<sup>4</sup>1 Corinthians 14:33, 40.

<sup>5</sup>John H. Walton, *The Lost World of Genesis One: Ancient Cosmology and the Origins Debate* (Downers Grove, IL: InterVarsity Press, 2009), 50.

6Ibid., 24.

- <sup>7</sup>For example, see H. Eugene Stanley, *Introduction to Phase Transitions and Critical Phenomena* (New York: Oxford University Press, 1971); Nigel Goldenfeld, *Lectures on Phase Transitions and the Renormalization Group* (Upper Saddle River, NJ: Addison-Wesley, 1992); *Phase Transitions: A Multinational Journal* (Abingdon, UK: Taylor & Francis, 1979–).
- <sup>8</sup>"Continuous transitions" are also referred to as "secondorder" transitions. In the case of ice, this is true only of the transition at the surface; bulk ice is a first-order or discontinuous transition. Second-order transitions are described by an order parameter  $\Psi$  which obeys the relationship  $\Psi(T) = (1 - T/T_c)^{\beta}$  for temperatures *T* below the critical temperature  $T_c$ . The critical exponent  $\beta$  is characteristic of the system.
- <sup>9</sup>ATLAS Collaboration, "Observation of a New Particle in the Search for the Standard Model Higgs Boson with the ATLAS Detector at the LHC," *Physics Letters B* 716 (2012): 1–12.

<sup>10</sup>"Phase Transitions," in Andrew Liddle and Jon Loveday, *The Oxford Companion to Cosmology* (New York: Oxford

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"Be fruitful and increase in number; fill the earth and subdue it. Rule over the fish in the sea and the birds in the sky and over every living creature that moves on the ground." –Genesis 1:28 University Press, 2008), http://www.oxfordreference.com /view/10.1093/acref/9780198608585.001.0001/acref -9780198608585-e-288.

- <sup>11</sup>For example, see Harry Cook, "Emergence: A Biologist's Look at Complexity in Nature," *Perspectives on Science and Christian Faith* 65, no. 4 (2013): 233–41, http://www.asa3.org/ASA/PSCF/2013/PSCF12-13Cook.pdf; Arthur Peacocke, *Theology for a Scientific Age: Being and Becoming Natural, Divine, and Human* (Oxford, UK: Oxford University Press, 1990).
- <sup>12</sup>For example, see Paul Davies, *The Accidental Universe* (Cambridge, UK: Cambridge University Press, 1982); Martin Rees, *Just Six Numbers: The Deep Forces That Shape the Universe* (New York: Basic Books, 2000); Alister E. McGrath, *A Fine-Tuned Universe: The Quest for God in Science and Theology* (Louisville, KY: Westminster John Knox Press, 2009); William Lane Craig, *Reasonable Faith: Christian Truth and Apologetics*, 3rd ed. (Wheaton, IL: Crossway Books, 2008).
- <sup>13</sup>Michael J. Behe, *The Edge of Evolution: The Search for the Limits of Darwinism* (New York: Free Press, 2007).
   <sup>14</sup>See for example, ibid.
- <sup>15</sup>Sjoerd L. Bonting, "Chaos Theology: A New Approach to the Science-Theology Dialogue," Zygon 34, no. 2 (1999):
- 323–32. <sup>16</sup>Hermann Gunkel, *Creation and Chaos in the Primeval Era and the Eschaton: A Religio-Historical Study of Genesis 1 and Revelation 12* (Grand Rapids, MI: Eerdmans, 2006).
- <sup>17</sup>John Walton, *The Lost World of Adam and Eve: Genesis 2–3 and the Human Origins Debate* (Downers Grove, IL: Inter-Varsity Press, 2015), 105.
- <sup>18</sup>John Walton and Brent Sandy, *The Lost World of Scripture: Ancient Literary Culture and Biblical Authority* (Downers Grove, IL: InterVarsity Press, 2013).
- <sup>19</sup>George Marsden, *Fundamentalism and American Culture*, 2nd ed. (New York: Oxford University Press, 2006).
- <sup>20</sup>Walton and Sandy, Lost World of Scripture, 280.
- <sup>21</sup>David C. Lindberg, *The Beginnings of Western Science: The European Scientific Tradition in Philosophical, Religious, and Institutional Context, Prehistory to A.D.* 1450, 2nd ed. (Chicago, IL: The University of Chicago Press, 2007).
- <sup>22</sup>Walton, Lost World of Genesis One, 21–34.
- <sup>23</sup>See also Bonting, "Chaos Theology."
- <sup>24</sup>Walton, Lost World of Adam and Eve, 116–18.
- <sup>25</sup>Ibid.
- <sup>26</sup>Ibid., 144.
- <sup>27</sup>Randy Isaac, "Chronology of the Fall," Perspectives on Science and Christian Faith 48, no. 1 (1996): 34, http://www .asa3.org/ASA/PSCF/1996/PSCF3-96Isaac.html.
- <sup>28</sup>See also Gunkel, Creation and Chaos in the Primeval Era and the Eschaton.
- <sup>29</sup>Peacocke, *Theology for a Scientific Age*, 79–80.
- <sup>30</sup>1 Corinthians 15:26.
- <sup>31</sup>Romans 8:19–23, English Standard Version (Wheaton, IL: Crossway Bibles, 2011).
- <sup>32</sup>Genesis 1:26–28.
- <sup>33</sup>Genesis 2:15.
- <sup>34</sup>Gregory R. Peterson, "The Created Co-creator: What It Is and Is Not," Zygon 39, no. 4 (2004): 827–40.
  <sup>35</sup>Revelation 21:26.

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## **Article**

## The Evolution of Creation Science, Part 3: Natural Selection and Convergent Evolution



Philip J. Senter

Philip J. Senter

Creation science (CS) is a discipline in which practitioners seek evidence to support a literal interpretation of the opening chapters of Genesis. A study of CS literature from the past fifty years reveals the following trends regarding the topics of natural selection (NS) and convergent evolution. Rejection of NS or some form of it has exceeded acceptance in both the twentieth and twenty-first centuries. Through both centuries, CS authors have consistently accepted stabilizing selection, have rejected NS as a factor in prebiotic chemical evolution and the evolution of biological complexity, and have disagreed as to whether to accept convergent evolution, directional selection, sexual selection, and NS as a driver of biological diversity within "created kinds." Acceptance of convergent evolution and directional selection within "created kinds" has risen in the twenty-first century among CS authors.

reation science (CS) is a discipline in which practitioners seek extrabiblical support for the young-Earth creationist (YEC) worldview. According to the (YEC) view, the literal wording of the book of Genesis accurately records past events, including the independent creation of all kinds of organisms about 6,000 years ago. The YEC view remains popular,<sup>1</sup> despite its contradiction by abundant physical evidence that Earth is billions of years old and that all organisms evolved from a common ancestor,<sup>2</sup> and despite biblical endorsement of a figurative rather than literal approach to Genesis and the rest of the Pentateuch.<sup>3</sup>

CS is voiced through its technical literature, which consists mainly of peer-reviewed journals that accept only manuscripts written from the YEC viewpoint. The earliest of these, *Creation Research Society Quarterly*, was launched in 1964. In a previous article,<sup>4</sup> Jared Mackey and I briefly delineated the history of proliferation of CS technical journals, and this history will not be repeated here.<sup>5</sup> CS technical literature has now become sufficiently vast and long lived to test for the presence of temporal trends in positions on various topics. Previously, we reported investigations into such trends in the topics of vestigial structures (as mainstream scientists understand them), biological degeneration (as CS practitioners understand it),<sup>6</sup> and beneficial mutations.<sup>7</sup> Here, I report an investigation into temporal trends in positions on natural selection and convergent evolution.

Natural selection (NS) is a type of biological evolution in which heritable variation exists in a population, and some variants are more successful than others at survival and reproduction. Through the generations, the traits in a population

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## **Article** *The Evolution of Creation Science, Part 3: Natural Selection and Convergent Evolution*

change as the more-successful variants produce more viable offspring than the other variants.<sup>8</sup> The success of a variant is called its fitness, which has led to the phrase "survival of the fittest" as a short description of natural selection. Traits that increase fitness in one situation may reduce fitness in other situations. For example, longer beak lengths once conferred greater fitness in Hawaiian honeycreepers (Drepanis coccinea), which consumed nectar from flowers that had a tubular shape, because the long beak enabled the birds to reach the nectar at the bottom of the tube. However, after deforestation in Hawaii drastically reduced the availability of trees with tubular flowers, forcing Hawaiian honeycreepers to glean nectar from nontubular flowers, longer beaks became a liability; subsequently, shorter beaks conferred greater fitness for Hawaiian honeycreepers.9

A few different kinds of NS exist. Directional selection is a form of NS in which a trait changes through the generations (e.g., horns are longer in later generations). Stabilizing selection is a form of NS in which a trait remains constant (e.g., horn length is the same in later generations as it was in earlier generations) by means of the elimination of less-fit variants.<sup>10</sup> Sexual selection is a form of NS in which, within a given sex, certain variants have greater reproductive success than others.<sup>11</sup> NS can lead to biological diversity as different environments favor different traits in populations living in different areas.<sup>12</sup> Mainstream scientists have documented<sup>13</sup> and accept the existence of NS and the forms of it that are listed above, and they hypothesize that NS played a role in the early evolution of macromolecules before the advent of the living cell.<sup>14</sup>

Convergent evolution is the acquisition of similar traits in different lineages. It can occur when members of those lineages occupy similar environments; these conditions lead NS to favor similar traits. Convergent evolution is called parallel evolution when closely related species with an identical precursor structure independently evolve similar specializations of that structure.<sup>15</sup>

Some CS authors accept the existence of convergent evolution, NS, and the forms of NS listed above, and others do not (tables 1, 2). Some CS authors also dispute the idea that NS is capable of successfully producing biological diversity, complex biological systems (e.g., chemical pathways), or complex anatomical structures. Some assert that NS should make all organisms identical, or that NS is based on circular reasoning or tautological error ("survival of the fittest," with the fittest defined as those that survive). Some dispute that NS could have been involved in the evolution of prebiotic macromolecules, the advent of sexual reproduction, the advent of biological symbioses, or the advent of human mental traits such as altruism and the ability to calculate.

## Materials and Methods

I sought to determine whether temporal trends exist in CS technical literature in the topics and subtopics identified in the previous two paragraphs. I used the methods described in our previous two articles, limiting the analysis to technical articles in CS literature and to conference abstracts in CS journals in which lengthy, referenced abstracts function as stand-alone articles. I searched through available PDF files of CS technical literature and searched visually through paper copies of journal volumes for which PDFs are not available.<sup>16</sup> For PDF searches, I used the search terms "natural selection," "mutation and selection," "survival of the fittest," "sexual selection," "converge," and "parallel."

As in our previous articles, I divided the duration of the CS movement into ten periods: 1964–1970 and nine subsequent periods of five years apiece from 1971–1975 to 2011–2015. I then compared the number of articles and authors accepting or rejecting various positions on the chosen topics and subtopics through time.

I calculated the percentage of twentieth-centuryarticles and authors accepting or rejecting each position, recording percentages with a precision of two significant digits; I repeated the procedure for twenty-first-century articles and authors. I then ran two-tailed *z*-tests on these proportions, to test for significant differences in the proportions between the two centuries. The *z*-tests were run with alpha set at a stringent 0.01 and then repeated with alpha set at a less-stringent 0.05 and a lenient 0.1 to account for small sample sizes.

## Results

I found 273 CS articles, by 132 authors, in which the authors took positions on NS (tables 1, 2). Rejection of NS in general or some form of it exceeded acceptance through all or most periods (figs. 1, 2). The predominant position (acceptance or rejection) flip-flopped

three times for directional selection and for NS as a driver of biological diversity, and once for sexual selection (figs. 1, 2). Stabilizing selection was consistently accepted. NS as a factor in prebiotic molecular evolution, and NS as a factor in the evolution of biological complexity, were consistently rejected. NS as a factor in the evolution of complex structures was consistently rejected, except for one instance in 2011 (fig. 2), in which an author accepted that antifreeze protein in eelpouts is a product of NS.<sup>17</sup> Acceptance that NS had been observed, assertion that NS should make all organisms identical, and characterization of NS as based on circular reasoning or tautological error remained at low levels (usually  $\leq$  5 authors) in all periods.

I found 55 articles by 34 authors, in which the authors took positions on convergent evolution (tables 1, 2). Rejection exceeded acceptance except in the period 2010–2015 (fig. 2).

With alpha set at 0.01, the two-tailed *z*-tests found a significant difference between the two centuries in only one proportion: number of articles rejecting directional selection (which dropped in the twentyfirst century). With alpha set at 0.05, the tests found additional significant differences between the two centuries in proportions of articles accepting directional selection (which rose), articles and authors rejecting sexual selection (which rose), authors accepting its existence (which dropped), and articles rejecting convergent/parallel evolution (which dropped) (fig. 3). With alpha set at 0.1, the tests found additional significant differences between the two centuries in proportions of authors accepting directional selection (which rose), authors rejecting it (which dropped), authors accepting NS as a driver of biological diversity (which dropped), articles accepting sexual selection (which dropped), authors rejecting convergent evolution (which dropped), and authors accepting it (which rose) (fig. 3).

In some cases, the sum of the percentages of CS articles or authors accepting and rejecting a concept exceeds 100% (table 1). This is due to occasional instances in which an author accepts a concept in one passage but rejects it in another passage in the same article (see table 2 for specific instances).

	1964– 1970	1971– 1975	1976– 1980	1981– 1985	1986– 1990	1991– 1995	1996– 2000	2001– 2005	2006– 2010	2011– 2015
	NS or Some Form of It									
Articles accepting	9	7	9	11	5	9	7	16	17	9
Authors accepting	7	7	7	11	5	11	7	11	15	7
Articles rejecting	19	14	10	16	7	15	19	34	33	19
Authors rejecting	11	12	10	10	6	14	11	26	25	11
% of articles accepting	36%	39%	60%	46%	42%	39%	29%	36%	36%	45%
% of authors accepting	54%	50%	54%	69%	45%	52%	44%	38%	48%	48%
% of articles rejecting	76%	78%	67%	67%	58%	65%	79%	77%	70%	55%
% of authors rejecting	85%	86%	77%	67%	55%	67%	69%	90%	81%	65%
			I	NS in Ge	neral					
Articles accepting	0	1	0	1	1	0	1	0	1	1
Authors accepting	0	1	0	1	1	0	1	0	1	1
Articles rejecting	4	6	4	4	0	4	1	2	11	7
Authors rejecting	3	6	4	4	0	4	1	4	13	6
% of articles accepting	0%	12.5%	0%	25%	100%	0%	50%	0%	9.1%	14%
% of authors accepting	0%	12.5%	0%	25%	100%	0%	50%	0%	7.1%	17%
% of articles rejecting	100%	75%	100%	100%	0%	100%	50%	100%	100%	100%
% of authors rejecting	100%	75%	100%	100%	0%	100%	50%	100%	93%	100%

**Table 1.** Numbers and percentages of CS articles and authors rejecting or accepting concepts related to natural selection

 and convergent evolution, through 2015.

## **Article** *The Evolution of Creation Science, Part 3: Natural Selection and Convergent Evolution*

#### Table 1 (cont'd)

	1964– 1970	1971– 1975	1976– 1980	1981– 1985	1986– 1990	1991– 1995	1996– 2000	2001– 2005	2006– 2010	2011– 2015
NS Has Been Observed										
Articles accepting	5	3	1	1	2	2	2	2	5	5
Authors accepting	4	4	1	1	2	2	2	2	6	6
% of articles accepting	20%	17%	6.7%	4.2%	17%	8.7%	8.3%	4.5%	19%	42%
% of authors accepting	31%	29%	7.7%	6.7%	18%	9.5%	12.5%	6.9%	19%	55%
NS as a Driver of Biological Diversity										
Articles accepting	1	2	1	1	1	4	1	1	3	5
Authors accepting	1	3	1	1	1	5	1	1	3	6
Articles rejecting	3	0	0	0	0	0	2	4	3	1
Authors rejecting	3	0	0	0	0	0	2	4	3	2
% of articles accepting	33%	100%	50%	100%	100%	100%	33%	50%	435	62.5%
% of authors accepting	33%	100%	50%	100%	100%	100%	33%	50%	43%	60%
% of articles rejecting	100%	0%	0%	0%	0%	0%	67%	80%	43%	13%
% of authors rejecting	100%	0%	0%	0%	0%	0%	67%	80%	43%	20%
Directional Selection										
Articles accepting	1	2		2		5	0	5	1	8
Authors accepting	1	2	1	2	0	5	0	1	5	10
Articles rejecting	1	1	2	2	1	2	2	4	2	10
	4	1	2	4	1	2	2	4	2	2
% of articles accepting	2	67%	220/	2004	I 0%	2	2	710/	67%	100%
% of authors accepting	20%	07.70	33%	29%	0%	0370	0%	670/	710/	100%
% of articles rejecting	100%	25%	100%	40% 57%	100%	0370	100%	57%	220/	25%
% of authors rejecting	100%	220/	100%	400/	100%	220/	100%	5770	200/	2070
	100%	3370	100%	40%	100 %	3370	100%	50%	29%	3370
		1	Se	xual Se	lection	1		I	[	1
Articles accepting					1	1	2	1	0	0
Authors accepting					1	1	2	1	0	0
Articles rejecting					0	1	2	4	2	1
Authors rejecting					0	1	1	2	2	1
% of articles accepting					100%	50%	67%	25%	0%	0%
% of authors accepting					100%	50%	100%	33%	0%	0%
% of articles rejecting					0%	50%	67%	100%	100%	100%
% of authors rejecting					05%	50%	50%	67%	100%	100%
Convergent Evolution										
Articles accepting	1	0	0	0	0	1	3	4	1	5
Authors accepting	1	0	0	0	0	1	3	3	1	4
Articles rejecting	5	3	2	1	5	4	5	6	8	2
Authors rejecting	3	2	1	1	5	6	5	3	10	1
% of articles accepting	17%	0%	0%	0%	0%	20%	43%	40%	11%	71%
% of authors accepting	25%	0%	0%	0%	0%	14%	43%	60%	10%	80%
% of articles rejecting	83%	100%	100%	100%	100%	80%	43%	60%	89%	29%
% of authors rejecting	75%	100%	100%	100%	100%	86%	43%	60%	100%	20%

Table 2.	CS	articles	that	express	acceptance	or	rejection	of	mutation,	natural	selection	(NS),	or	convergent	evolution.
----------	----	----------	------	---------	------------	----	-----------	----	-----------	---------	-----------	-------	----	------------	------------

Author and year	Position on natural selection	Position on convergent evolution
Lammerts, 1964 <sup>1</sup>	Reject (DS)	
Tinkle, 1964 <sup>2</sup>	Accept (SS: Obs), Reject (Com)	
Zimmerman, 1964 <sup>3</sup>	Reject (PCE)	
Barnes, 1965 <sup>4</sup>	Reject (PCE)	
Howe, 1965 <sup>5</sup>		Reject, CD
Lammerts, 1965 <sup>6</sup>	Reject (Sym)	
Shute, 1965 <sup>7</sup>	Reject (CoS: numerous miscellaneous examples; Sym)	
Howard, 1966 <sup>8</sup>	Accept (SS, DS)	
Klotz, 1966 <sup>9</sup>	Reject (G)	Accept
Lammerts, 1966 <sup>10</sup>	Reject (BD)	
Armstrong, 1967 <sup>11</sup>	Accept (SS)	
Armstrong, 1967 <sup>12</sup>	Reject (G), CR	
Howe, 1967 <sup>13</sup>		Reject
Lammerts, 1967 <sup>14</sup>	Accept (SS: Obs), Reject (DS)	
Armstrong, 1968 <sup>15</sup>	Reject (G), CR	
Howe, 1968 <sup>16</sup>	Accept (BD)	
Tinkle, 196817	Reject (CoS: flowers)	
Armstrong, 1969 <sup>18</sup>	Reject (Sym)	
Howe, 1969 <sup>19</sup>	Accept (SS)	
Lammerts, 1969 <sup>20</sup>	Reject (DS)	
Marsh, 1969 <sup>21</sup>		Reject, EA
Shute, 1969 <sup>22</sup>		Reject, EA
Tinkle, 196923	Accept (SS: Obs)	
Tinkle, 1969 <sup>24</sup>	Reject (CoS: spadix-and- spathe structure of the jack-in-the-pulpit; differ- ences between larval and adult dragonfly)	
Williams, 1969 <sup>25</sup>	Reject (G)	
Armstrong, 1970 <sup>26</sup>	Reject (CoS)	
Cousins, 1970 <sup>27</sup>	Accept (Obs), Reject (PCE)	
Mosher & Tinkle, 1970 <sup>28</sup>	Accept (SS: Obs); Reject (CoS), <i>CR</i>	
Shute, 1970 <sup>29</sup>		Reject, EA
Smith, 1970 <sup>30</sup>	Reject (BD)	
Armstrong, 1971 <sup>31</sup>	Reject (G) Iden	Reject
Armstrong, 1971 <sup>32</sup>	Reject (G)	
Howe & Davis, 1971 <sup>33</sup>	Accept (BD; G: Obs)	
Ouweneel, 1971 <sup>34</sup>	Accept (BD, SS)	
Tinkle, 197135	Reject (G)	
Armstrong, 1972 <sup>36</sup>	Reject (Com), Iden	
Holroyd, 1972 <sup>37</sup>	Reject (G), Iden	
Morris, 1972 <sup>38</sup>	Reject (G)	
Armstrong, 1973 <sup>39</sup>		Reject, EA

**Key: BD** = biological diversity as a product of NS. **CD** = assertion or implication that apparent convergent evolution is evidence of a common designer. **Com** = biological complexity as a product of NS. **CoS** = complex structures as products of NS. **CR** = assertion that NS or "survival of the fittest" is based on circular reasoning or tautological error. **DS** = directional selection. **EA** = assertion that the idea of convergent evolution is a way to explain away similarities in unrelated organisms. **G** = NS in general. **HMT** = human mental traits as products of NS. **Iden** = assertion or implication that NS should

Author and year	Position on natural selection	Position on convergent evolution
Garrido, 197340	Accept (SS), Reject (CoS)	
McCone, 197341	Accept (DS: Obs)	
Telfair, 197342	Accept (DS), Reject (G), <i>CR</i>	
Lammerts & Howe, 1974 <sup>43</sup>	Accept (SS: Obs)	
Armstrong, 197544	Reject (DS)	
Helmick, 197545	Reject (PCE)	
Howe, 197546		Reject, EA
Lammerts, 197547	Reject (G)	
Murphy & Howe, 1975 <sup>48</sup>	Reject (Com, CoS: chemi- cal pathways in photo- synthesis; bat wing)	
Ouweneel, 1975 <sup>49</sup>	Accept (SS), Reject (Com: genetic controls in homeotic phenomena)	
Clark, 197650	Reject (HMT)	
Davidheiser, 1976 <sup>51</sup>	Accept (SS: Obs)	
Haines, 1976 <sup>52</sup>	Accept (SS), Reject (PCE)	
Siegler, 197653	Reject (BD)	
Smith, 197654	Reject (G)	
Tinkle, 197655	Accept (SS)	
Lammerts, 1977 <sup>56</sup>	Reject (G)	
Ouweneel, 197757	Accept (SS)	
Poettcker, 197758	Accept (SS), Reject (G)	
Tinkle, 1977 <sup>59</sup>	Accept (SS), Reject (DS, SR)	
Walton, 197760	Reject (G)	
Howe, 197861	Accept (SS)	
Smith, 197862	Reject (G)	
Woodmorappe, 1978 <sup>63</sup>		Reject, CD
Hedtke, 197964	Reject (DS)	
Howe, 197965	Accept (BD)	
Ancil, 198066	Accept (SS, BD)	
Roth, 198067	Reject (CoS)	
Tinkle, 198068	Reject (PCE)	
Woodmorappe, 1980 <sup>69</sup>		Reject
Wrangham, 1980 <sup>70</sup>	Accept (DS, SS)	
Cheek, 1981 <sup>71</sup>	Accept (G: Obs)	
Hedtke, 198172	Reject (G)	
Howe, 198173	Accept (DS)	
Lammerts, 1981 <sup>74</sup>	Reject (DS)	
Tinkle, 198175	Reject (Com), Iden	
Brown, 1982 <sup>76</sup>	Accept (SS)	
Howe, 1982 <sup>77</sup>	Reject (Com: genes that help a plant re-spout after a fire)	

make all organisms identical. **Obs** = acceptance that the phenomenon has been observed to occur. **PCE** = influence of NS on prebiotic chemical evolution. **SR** = sexual reproduction as a product of NS. **SS** = stabilizing selection. **Sym** = symbioses as products of NS. **SxS** = sexual selection. **Note** that authors who accept SS but reject G usually specify that they reject NS as a driver of macroevolution. Names of biological structures and processes listed after "Com" and "CoS" are those that the author(s) claimed are too irreducibly complex to have evolved by NS.

## **Article** *The Evolution of Creation Science, Part 3: Natural Selection and Convergent Evolution*

#### Table 2 (cont'd)

Author and year	Position on natural selection	Position on convergent evolution
Jones, 1982 <sup>78</sup>	Reject (DS)	Reject, CD
Lammerts, 1982 <sup>79</sup>	Reject (G)	
Moore, 1982 <sup>80</sup>	Accept (SS)	
Smith, 1982 <sup>81</sup>	Accept (SS)	
Tinkle, 1982 <sup>82</sup>	Accept (SS)	
Bluth, 198383	Accept (SS), Reject (DS)	
Lambert, 1983 <sup>84</sup>	Accept (DS)	
Lammerts, 198385	Reject (DS)	
Riss. 1983 <sup>86</sup>	Reject (G)	
Hedtke, 1984 <sup>87</sup>	Accept (SS), Reject (CoS)	
Lammerts, 1984 <sup>88</sup>	Accept (SS), Reject (DS)	
Hamilton, 1985 <sup>89</sup>	Reject (CoS: cephalopod eye; human eye)	
Lammerts, 1985 <sup>90</sup>	Reject (Com)	
Smith, 1985 <sup>91</sup>	Reject (G)	
Hamilton, 1986 <sup>92</sup>	Reject (CoS: eye of jumping spider)	
Leslie, 198693	Reject (DS)	
Moore, 198694	Accept (SS)	
Sanders & Howe, 1986 <sup>95</sup>	Reject (CoS: food- catching basket of dragonfly; click apparatus of click beetle)	
Butt, 1987 <sup>96</sup>	Accept (SS, SxS)	
Hamilton, 1987 <sup>97</sup>	Reject (CoS: cephalopod eye; human eye)	Reject, CD
Glover, 198898		Reject, <i>EA</i>
Hamilton, 198899	Reject (CoS: tetrapod eye)	
Mehlert, 1988100		Reject, EA
Williams, 1988 <sup>101</sup>	Reject (CoS: spider web production and complexity)	
Gish, 1989 <sup>102</sup>	Accept (SS: Obs)	
von Fange, 1989 <sup>103</sup>		Reject
Arndts, 1990 <sup>104</sup>		Reject, EA
Bergman, 1990 <sup>105</sup>	Accept (SS)	-
Hedtke, 1990 <sup>106</sup>	Reject (CoS)	
Wise, 1990 <sup>107</sup>	Accept (BD, G: Obs)	
Bergman, 1991108	Reject (CoS)	
Culp, 1991 <sup>109</sup>	Accept (SS)	
Davidheiser, 1991 <sup>110</sup>	Accept (DS: Obs)	
Hamilton, 1991 <sup>111</sup>	Reject (CoS: fish eye; tetrapod eye), <i>CR</i>	
Kouznetsov, 1991 <sup>112</sup>	Accept (SS) (DS: Obs)	
Williams, Howe & White, 1991 <sup>113</sup>	Reject (Com: millipede defense system)	Reject, CD
Bergman, 1992 <sup>114</sup>	Accept (SxS), Reject (CoS, PCE), <i>CR</i>	
Brand & Carter, 1992 <sup>115</sup>	Accept (BD)	
Crofut, 1992 <sup>116</sup>	Reject (DS)	
Kofahl, 1992117	Reject (G)	
Bergman, 1993 <sup>118</sup>	Accept (DS: Obs, SS), Reject (DS, SxS) <i>Iden</i> , <i>CR</i>	
Brand & Gibson, 1993 <sup>119</sup>	Accept (BD, SS), Reject (CoS)	
Hamilton, 1993 <sup>120</sup>	Reject (CoS)	

Author and year	Position on natural selection	Position on convergent evolution
Hoffman, 1993121	Reject (G), CR	
Lumsden, 1993 <sup>122</sup>	Reject (CoS: plant alkaloids)	
Mehlert, 1993 <sup>123</sup>		Reject, EA
Armitage, 1994 <sup>124</sup>	Reject (CoS: shapes of diatoms)	
Gibson, 1994125		Accept
Kaufmann, 1994 <sup>126</sup>	Reject (CoS: human body)	
Lester, 1994127	Accept (BD, DS, SS)	
ReMine, 1994 <sup>128</sup>	Reject (G)	Reject
Bergman, 1995129	Reject (G)	
Lutz, 1995 <sup>130</sup>	Reject (CoS: feathers)	
Mehlert, 1995131	Accept (BD, SS)	
Ulm, 1995 <sup>132</sup>		Reject, CD
Wise, 1995 <sup>133</sup>	Accept (DS)	
Bergman, 1996 <sup>134</sup>	Accept (SS: Obs), Reject (SR, SxS)	
Calais & Mehlert, 1996 <sup>135</sup>	Accept (SS)	
Colwell, 1996 <sup>136</sup>	Reject (G) CR	
Gibson, 1996 <sup>137</sup>	Reject (BD)	
Sarfati, 1996 <sup>138</sup>	Reject (PCE)	
Wieland, 1996 <sup>139</sup>	Reject (CoS)	
Armitage, 1997 <sup>140</sup>	Reject (Sym)	
Bergman, 1997 <sup>141</sup>	Accept (SS)	
Deckard, 1997142	Accept (G)	
Robinson, 1997 <sup>143</sup>		Accept
Sarfati, 1997 <sup>144</sup>	Accept (BD)	
Wieland, 1997 <sup>145</sup>	Accept (SxS)	
Armitage, 1998146	Reject (Com)	
Batten, 1998147	Reject (Com, PCE)	
Bergman, 1998 <sup>148</sup>	Reject (Sym)	
Bergman, 1998149	Reject (Sym)	
Bergman, 1998 <sup>150</sup>	Reject (CoS)	
Howe, 1998 <sup>151</sup>	Reject (Sym)	
McGinley, 1998152	Accept (BD: Obs)	
Oard, 1998 <sup>153</sup>	Accept (SS), Reject (DS)	Accept, Reject
Penrose, 1998154	Reject (DS)	
Robinson & Cavanaugh, 1998 <sup>155</sup>		Accept
Sarfati, 1998 <sup>156</sup>	Reject (PCE)	
Wise, 1998157		Reject
Woodmorappe, 1998 <sup>158</sup>		Reject, <i>EA</i>
Hedtke, 1999 <sup>159</sup>	Reject (CoS)	
Kaufmann, 1999 <sup>160</sup>	Reject (PCE)	
Sarfati, 1999 <sup>161</sup>	Reject (CoS: double-sieve enzymes)	
Armitage & Lumsden, 2000 <sup>162</sup>		Reject
Bergman, 2000 <sup>163</sup>	Reject (PCE)	
Bergman, 2000 <sup>164</sup>	Reject (SxS)	
Woodmorappe, 2000 <sup>165</sup>		Reject

#### Table 2 (cont'd)

Author and year	Position on natural selection	Position on convergent evolution
Bergman, 2001 <sup>166</sup>	Reject (CoS: transposons)	
Bergman, 2001167	Accept (SS)	
Bergman, 2001 <sup>168</sup>		Reject, EA
Burgess, 2001 <sup>169</sup>	Reject (SxS)	
Gurney, 2001 <sup>170</sup>	Reject (CoS: human eye)	
Laughlin, 2001 <sup>171</sup>	Accept (SS)	
Mastropaolo, 2001 <sup>172</sup>	Reject (BD, CoS)	
Oard, 2001 <sup>173</sup>		Reject
Oard, 2001 <sup>174</sup>		Reject, EA
Wood & Cavanaugh, 2001 <sup>175</sup>		Accept
Batten, 2002 <sup>176</sup>	Reject (Com: C <sub>4</sub> chemistry in plants)	
Bergman, 2002177	Accept (SS), Reject (BD)	
Bergman, 2002 <sup>178</sup>	Reject (CoS: giraffe neck)	
Bergman, 2002179		Reject, EA
Gurney, 2002 <sup>180</sup>	Accept (SS)	
Kofahl, 2002181	Reject (CoS)	
Leyfield, 2002182	Accept (BD)	
Wood, 2002 <sup>183</sup>		Accept
Woodmorappe, 2002 <sup>184</sup>		Reject, EA
Batten, 2003185	Accept (DS)	
Bergman, 2003 <sup>186</sup>	Accept (DS: Obs; SS), Reject (DS)	
Manning, 2003 <sup>187</sup>	Reject (CoS: insect flight systems)	
Swindell, 2003 <sup>188</sup>	Reject (CoS, Com: pro- teins; chemical pathways in photosynthesis)	
Taylor, 2003 <sup>189</sup>	Accept (DS: Obs), Reject (HMT)	
Truman, 2003190	Reject (PCE)	
Woodmorappe, 2003 <sup>191</sup>	Reject (CoS)	
Woodmorappe, 2003 <sup>192</sup>	Reject (BD)	
Woodmorappe, 2003 <sup>193</sup>	Accept (DS)	
Wright, 2003194	Reject (SxS)	
Armitage & Howe, 2004 <sup>195</sup>	Reject (Com: vegetative reproduction in lichens; lichens' resistance to low temperatures)	
Batten, 2004 <sup>196</sup>	Reject (Com: protein editing; mRNA editing; the killer T-cell system)	
Batten, 2004197	Reject (Sym)	
Bell, 2004 <sup>198</sup>	Accept (SS), Reject (Com)	
Bergman, 2004199	Reject (SxS)	
Bergman, 2004 <sup>200</sup>	Accept (SS, SxS), Reject (SxS)	
Bergman, 2004 <sup>201</sup>	Accept (SS)	
Harrub & Thompson, 2004 <sup>202</sup>	Reject (SR)	
Khomenko, 2004 <sup>203</sup>	Accept (SS)	

Author and year	Position on natural selection	Position on convergent evolution
May, Thompson, & Harrub, 2004 <sup>204</sup>	Reject (G)	
Murdock, 2004 <sup>205</sup>	Reject (DS)	
Schragin, 2004 <sup>206</sup>	Reject (Sym)	
Thompson &	Reject (HMT)	
Harrub, 2004 <sup>207</sup>		
Thompson & Harrub, 2004 <sup>208</sup>	Reject (SR)	
Wilson, 2004 <sup>209</sup>	Reject (G)	
Woodmorappe, 2004 <sup>210</sup>		Accept
Bergman, 2005 <sup>211</sup>	Accept (DS), Reject (DS)	
Bergman, 2005 <sup>212</sup>	Accept (SS), Reject (Com: genetic code; PCE)	
Bergman, 2005 <sup>213</sup>		Reject
Brand & Schwab, 2005 <sup>214</sup>	Reject (CoS: sensory structures)	
Catchpoole, 2005 <sup>215</sup>	Reject (Com: the process of producing flattening in leaves)	
DeWitt, 2005 <sup>216</sup>	Reject (Com)	
Sarfati, 2005 <sup>217</sup>	Reject (Com: chemi- cal pathways in photosynthesis)	
Truman, 2005 <sup>218</sup>	Reject (CoS: ubiquitin protein)	
Williams, 2005 <sup>219</sup>	Reject (SR)	
Williams, 2005220	Accept (DS)	
Wise, 2005 <sup>221</sup>	Accept (SS), Reject (BD)	Accept
Armitage & Howe, 2006 <sup>222</sup>	Reject (CoS)	
Bergman, 2006223	Accept (SS)	
Biswas, 2006 <sup>224</sup>	Accept (SS)	
Brand, 2006 <sup>225</sup>	Reject (DS)	
Demme, 2006 <sup>226</sup>	Accept (G)	
Henry, 2006 <sup>227</sup>	Accept (BD)	
Stoltzmann, 2006 <sup>228</sup>	Reject (CoS: human eye)	
Truman, 2006 <sup>229</sup>	Reject (PCE)	
Wise, 2006 <sup>230</sup>		Accept
Armitage, 2007 <sup>231</sup>	Accept (DS)	
Bergman, 2007 <sup>232</sup>	Reject (SxS)	
Borger & Truman, 2007 <sup>233</sup>	Reject (Com: mRNA regulation)	
Borger & Truman, 2007 <sup>234</sup>	Reject (G)	Reject
Jaroncyk & Doyle, 2007 <sup>235</sup>		Reject, <i>EA</i>
Sarfati, 2007 <sup>236</sup>	Reject (Com: DNA scrunching; PCE)	
Truman & Borger, 2007 <sup>237</sup>	Reject (Com: the DNA code)	
Truman & Borger, 2007 <sup>238</sup>	Reject (Com)	
Truman & Borger, 2007 <sup>239</sup>		Reject
Smith, 2007 <sup>240</sup>	Accept (SS), Reject (Sym)	
Williams, 2007 <sup>241</sup>	Reject (PCE)	
Williams, 2007 <sup>242</sup>	Reject (G)	

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#### Table 2 (cont'd)

Author and year	Position on natural selection	Position on convergent evolution
Armitage, 2008 <sup>243</sup>		Reject
Anderson & Purdom, 2008 <sup>244</sup>	Reject (Com)	
Baumgardner, Sanford, Brewer, Gibson, and ReMine, 2008 <sup>245</sup>	Reject (G)	
Bergman, 2008 <sup>246</sup>	Reject (CoS: arthropod compound eye; fish eye; human eye)	
Bergman, 2008 <sup>247</sup>	Accept (SS: Obs)	
Borger, 2008 <sup>248</sup>	Accept (SS), Reject (Com, PCE)	
Borger, 2008 <sup>249</sup>	Accept (SS), Reject (BD)	
Lightner, 2008 <sup>250</sup>	Accept (DS: Obs)	
Lightner, 2008 <sup>251</sup>	Reject (BD)	
Liu, 2008 <sup>252</sup>	Reject (Com)	
Purdom, 2008 <sup>253</sup>	Accept (DS: Obs)	
Purdom & Anderson, 2008 <sup>254</sup>	Accept (DS: Obs), Reject (Com)	
Sanford, Baum- gardner, Brewer, Gibson, and ReMine, 2008 <sup>255</sup>	Reject (G)	
Truman & Borger, 2008 <sup>256</sup>	Reject (G)	
Truman & Borger, 2008 <sup>257</sup>	Reject (Com)	
Williams, 2008 <sup>258</sup>	Reject (G)	
Williams, 2008 <sup>259</sup>	Accept (BD)	
Criswell, 2009 <sup>260</sup>	Accept (DS: Obs), Reject (BD)	
Doyle, 2009 <sup>261</sup>		Reject, EA
Howe, 2009 <sup>262</sup>	Reject (BD)	
Hennigan, 2009 <sup>263</sup>	Reject (Sym)	
Larssen, 2009 <sup>264</sup>	Reject (G), CR	
Lightner, 2009 <sup>265</sup>	Reject (G)	
Liu & Soper, 2009 <sup>266</sup>		Reject
Oard, 2009 <sup>267</sup>	Accept (SS)	
Sarfati, 2009 <sup>268</sup>	Reject (SxS)	
Stevens, 2009 <sup>269</sup>	Reject (CoS): animal wing plus relevant cerebral circuitry	
Wise, 2009 <sup>270</sup>	Reject (G)	
Woetzel, 2009271	Accept (SS)	
Bartlett, 2010272	Reject (CoS: flagellum)	
Bergman, 2010273	Reject (G)	
Bergman, 2010274		Reject
Lightner, 2010 <sup>275</sup>	Reject (Com)	
Oard, 2010 <sup>276</sup>		Reject
Smith, 2010 <sup>277</sup>	Reject (G)	
Catchpoole, 2011 <sup>278</sup>	Accept (BD, DS)	
Doyle, 2011 <sup>279</sup>	Accept (BD)	
Doyle, 2011 <sup>280</sup>	Accept (BD, CoS)	
Lightner, 2011 <sup>281</sup>	Reject (BD, Sym)	
Oard, 2011282	Accept (BD)	Reject
Oard, 2011 <sup>283</sup>		Reject, EA
Pendragon, 2011 <sup>284</sup>	Accept (DS)	

Author and year	Position on natural selection	Position on convergent evolution
Pendragon & Winkler, 2011 <sup>285</sup>	Accept (BD)	
Statham, 2011286	Reject (SxS)	
White, 2011 <sup>287</sup>	Accept (DS)	
Gaskill & Thomas, 2012 <sup>288</sup>	Reject (BD, DS)	
Lightner, 2012 <sup>289</sup>		Accept
Truman, 2012290	Reject (PCE)	
Enyart, 2013 <sup>291</sup>	Reject (DS)	
Jeanson, 2013 <sup>292</sup>	Reject (G)	
Joubert, 2013 <sup>293</sup>	Accept (BD)	
Lee, Horstemeyer, Seely, & Williams, 2013 <sup>294</sup>	Reject (CoS): woodpecker beak	
Lightner, 2013 <sup>295</sup>		Accept
Line, 2013 <sup>296</sup>	Accept (BD)	
Rupe & Sanford, 2013 <sup>297</sup>	Reject (G)	
Arment, 2014 <sup>298</sup>		Accept
Carter, 2014 <sup>299</sup>	Accept (G: Obs)	
Guliuzza, 2014 <sup>300</sup>	Reject (G)	
Guliuzza, 2014301	Reject (G)	
Guliuzza, 2014302	Reject (G)	
Joubert, 2014 <sup>303</sup>	Reject (G)	
Lightner, 2014 <sup>304</sup>	Reject (G)	
Lightner, 2014 <sup>305</sup>	Reject (Com: grass- hopper mouse immunity to scorpion venom)	
Lightner, 2014 <sup>306</sup>	Reject (Com)	
Bergman & Snow, 2015 <sup>307</sup>	Reject (CoS: avian respi- ratory system)	
Cook, 2015 <sup>308</sup>	Reject (HMT)	
Gillen, Conrad, & Cargill, 2015 <sup>309</sup>	Accept (DS: Obs)	
Lightner, 2015310	Accept (SS: Obs)	
Stoltzmann, 2015 <sup>311</sup>	Reject (CoS: human eye)	
Liu, 2015 <sup>312</sup>	Accept (DS: Obs)	
Liu, 2015 <sup>313</sup>	Accept (DS: Obs)	
Tan, 2015 <sup>314</sup>	Reject (CoS): proteins	Accept
Truman, 2015 <sup>315</sup>		Accept
Williams, 2015 <sup>316</sup>	Accept (DS)	
Williams 2015317	Accent (SS)	

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Figure 2. Temporal trends in the technical literature of creation science through 2015, regarding topics relating to natural selection and convergent evolution.

Key for Figures 1 & 2: Solid lines indicate articles, and dashed lines indicate authors; where no dashed line is visible, the number of authors equals the number of articles. Gray indicates acceptance, and black indicates rejection. The absence of data on positions toward stabilizing selection in the period 2010–2015 indicates a lack of authors taking a position on that topic during that period. NS = natural selection.

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Figure 3. Percentages of articles and authors accepting or rejecting natural selection and related phenomena in the technical literature of creation science in the twentieth and twenty-first centuries, through 2015.

Key: Solid lines indicate articles, and dashed lines indicate authors. Gray indicates acceptance, and black indicates rejection. Lines with a circled "au" (authors) or "ar" (articles) are cases in which two-tailed z-tests found a significant difference in the proportion between the twentieth and twenty-first centuries. For circled "au" and "ar," a triple circle indicates that two-tailed z-tests found a significant difference between centuries when alpha was set at 0.1, 0.05, and 0.01; a double circle indicates that the tests found a significant difference when alpha was set at 0.1 and at 0.05; a single circle indicates that the tests found a significant difference between a previous study, in which the difference between centuries was described but not illustrated. See Philip J. Senter and Jared J. Mackey, "The Evolution of Creation Science, Part 2: Beneficial Mutations," *Perspectives on Science and Christian Faith* 69, no. 2 (2017): 87–97.

### Discussion

## *NS in General and in Relation to Macroevolution*

Through both centuries, more CS authors have rejected than have accepted NS. Often, rejection was based on nonsensical arguments. One author rejected NS on the basis that the concept of NS is not intuitively grasped by children,<sup>18</sup> by which reasoning one ought also to reject higher mathematics, particle physics, and molecular genetics. Another argued that "selection would be by characteristics, but inheritance would occur by genes,"19 neglecting to recognize that genes produce characteristics, and therefore selection occurs on both simultaneously. One author asserted that NS should increase fecundity, and rejected NS because simple organisms often have great fecundity, incorrectly equating "simple" with "less fit."20 According to another author, some animals have eyes that are better than they need, whereas NS (allegedly) should make only structures that are adequate for current needs.<sup>21</sup> One author argued that the spread of antibiotic resistance in bacteria cannot be due to NS, because the transference of R-plasmids between bacteria contradicts the (alleged) prediction by NS that an organism will not give an advantage to its competitors.<sup>22</sup> However, that author failed to recognize that directional selection occurs when a trait increases within a population; this is exactly what happens when antibiotic resistance is spread via the transmission of R-plasmids.

Two authors used scripture to justify their rejection of NS. According to one author, NS contradicts Ecclesiastes 9:11: "The race is not to the swift, nor the battle to the strong,"<sup>23</sup> a passage that is a creative bemoaning of the observation that people often get rewards that they do not deserve; the passage is irrelevant to NS among nonhuman organisms. Another author correctly pointed out that NS requires death, and according to the literal sense of scripture, there was no death before the Fall of humans in the Garden of Eden, and so humans could not have evolved by NS if scripture is to be taken literally.<sup>24</sup>

In some cases, CS authors used misinformation to support denial of NS. One author claimed that NS could not have occurred, because no morphological intermediates are found in the fossil record,<sup>25</sup> a false claim that is contradicted by enough examples to fill volumes.<sup>26</sup> Another author claimed that, whereas NS theory predicts that predators will select for superior prey by preying on the weak, in reality, predators select prey randomly.<sup>27</sup> That claim is falsified by data from numerous studies that show that predators do tend to preferentially target more-vulnerable prey (the young and the weak,<sup>28</sup> eggs in nests that are easier to find,<sup>29</sup> etc.). In fact, numerous studies have documented NS-mediated enhancement of antipredator defenses in prey species as a result of selection pressure from predators.<sup>30</sup> According to some, most or all mutations are deleterious, and NS would require too many beneficial mutations to be plausible.<sup>31</sup> However, recent research shows that beneficial mutations occur sufficiently often to drive NS.<sup>32</sup>

CS authors often rejected NS for contradictory reasons. One author argued that NS would be too slow to account for macroevolution,<sup>33</sup> whereas another argued that it would be too fast.<sup>34</sup> One author asserted that NS would require mutations to accumulate, but instead they get weeded out,<sup>35</sup> whereas other authors claimed that NS requires mutations to get weeded out, but instead they accumulate.<sup>36</sup> Some authors claimed that differences between organisms were evidence against NS,<sup>37</sup> whereas others claimed that similarities between organisms were evidence against NS.<sup>38</sup>

Authors proffering the third pair of opposing positions often gave specific examples. One author argued that plants that give insects indigestion could not have evolved that defense by NS, because other plants that do not give insects indigestion do exist.<sup>39</sup> Another author denied NS because simple organisms still exist, whereas NS (allegedly) should make all organisms complex.<sup>40</sup> How, asked one author, could NS have produced

the long neck of the giraffe and the short neck of the pig; the hard shells of some turtles and the soft shells of others; the great size of the whale and the small size of the shrew ... the great speed of the jackrabbit and the slow speed of the woodchuck; and so on.<sup>41</sup>

Summarizing the position, one author stated that "according to natural selection, all animals would eventually evolve a similar, best type which could survive in a variety of wild situations."<sup>42</sup>

Authors taking the opposite stance also cited specific examples, expressing doubt that NS could have produced the similarity between monarch and viceroy butterflies (*Danaus plexippus* and *Limenitis archippus*)<sup>43</sup>

or the similar lifestyles of various lineages of flies that "live in similar ways on crabs."<sup>44</sup> One author even simultaneously took both opposing positions in a single article, citing similarities between animals (invertebrate and vertebrate eyes) as evidence against NS, and then citing differences between animals (some animals' ears are small while others are large) as evidence against NS.<sup>45</sup>

Numerous CS authors listed various symbiotic relationships as examples of phenomena that NS could not have produced (table 2). Such assertions are based on the implicit assumption that if two organisms are mutually interdependent, then they must have been created at the same time, because neither could have survived if it came into being without the other. However, many examples exist of mutual interdependence in species that, demonstrably, were previously not mutually interdependent because they did not previously inhabit the same area.<sup>46</sup> Such examples falsify this type of argument against NS.

The concept of irreducible complexity has been a popular argument against NS among CS authors. According to this concept, some biological structures or processes are too complex to have evolved by NS, because intermediate stages would not be viable or useful. Examples cited by CS authors are listed in table 2. It is noteworthy that for several of those examples, the hypothesis that the structure or process is irreducibly complex is falsified by the known existence of intermediate forms, the existence of which demonstrates that intermediate forms are viable (appendix 1).

CS authors who accept NS understandably accept that it has produced changes only within baramins ("created kinds" of organisms). Because CS authors do not accept macroevolution, they consistently deny that NS could have produced macroevolutionary phenomena such as prebiotic molecular evolution, sexual reproduction, complex biological processes and structures, and the evolution of human mental traits from precursor states in nonhuman ancestors. Arguments against NS in prebiotic molecules usually involve incorrect assumptions. Some CS authors asserted that NS can act only on living cells,47 an assertion that has been falsified by experimental observations of NS acting on nucleic acids in vitro.48 One author asserted that prebiotic molecules could not undergo NS because such molecules do not self-replicate, and NS can only act on self-replicat-

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ing entities.<sup>49</sup> However, recent research shows that some such molecules—including examples of peptides, double-stranded nucleic acids, and RNA—can accomplish self-replication.<sup>50</sup>

CS authors consistently reject NS as compatible with the origin of sexual reproduction. According to such authors, NS would weed out any mutation that caused an organism to undergo "the dilution of 50% of its genes."<sup>51</sup> As one pair of authors put it, "the Darwinian 'survival of the fittest' mantra does not compute with a sexual practice that selectively only passes one half of one's genes to successive progeny."<sup>52</sup>

However, dilution by 50% does not affect the entire genome but affects only those genes for which an organism is heterozygous. An allele for which an organism is homozygous is necessarily passed on by sexual reproduction. Moreover, recent research indicates that sexual reproduction confers advantages upon offspring, in accordance with the naysayers' expectations of a system that is a product of NS. Genetic recombination during sexual reproduction dramatically reduces the rate of accumulation of deleterious mutations<sup>53</sup> and concentrates beneficial mutations, increasing the rate of adaptation.<sup>54</sup> It also appears to unlink deleterious mutations from beneficial mutations, allowing those deleterious mutations to be selected out of the genome.<sup>55</sup> In addition, sexual selection, which depends on the presence of sexual reproduction, is advantageous for gene propagation. It decreases mutation load and increases fitness,<sup>56</sup> and traits that are favored by sexual selection often have survival value.57

According to some CS authors, human mental traits could not have evolved by NS. One author claimed that if the mind is a product of NS, then its own conclusions—including the conclusion that NS exists—are unreliable.<sup>58</sup> That argument is a non sequitur. Another author asserted that human altruism was not a product of NS.<sup>59</sup> However, recent research indicates that the specifically human forms of altruism confer selective advantages;<sup>60</sup> this is consistent with their having arisen via NS. Other authors claimed that musical ability, the ability to calculate, and consciousness could not be products of NS because they have no survival value.<sup>61</sup>

Recent findings oppose such claims. By definition, NS can act upon a trait if the trait is heritable and

adaptively relevant. A trait is heritable if it is a product of an anatomical structure, which in turn is a product of genes. It is adaptively relevant if it confers an advantage, especially an increased likelihood of survival and/or reproduction. Human musical ability has functions that are adaptively relevant,<sup>62</sup> and its association with specific brain regions shows that it has an anatomical basis.<sup>63</sup> Consciousness<sup>64</sup> and the ability to calculate<sup>65</sup> are also adaptively relevant and associated with specific brain regions.

Moreover, potential evolutionary precursors for such "human" traits are known in nonhuman animals. Numerous animals-including even insects<sup>66</sup> and fishes<sup>67</sup>-have the ability to count, and a rudimentary ability to calculate is known in birds<sup>68</sup> and primates.<sup>69</sup> Thus a potential evolutionary precursor to the human ability to calculate exists in nonhuman animals. Likewise, certain aspects of human consciousness exist in some animals;<sup>70</sup> therefore, human consciousness could have evolved from a nonhuman precursor. In addition, altruism<sup>71</sup> and certain other traits associated with human mentality (e.g., tool use,<sup>72</sup> cultures,<sup>73</sup> planning ahead,<sup>74</sup> sense of fairness,<sup>75</sup> theory of mind<sup>76</sup>) are present in other primates; these facts suggest that human mentality could have arisen from a precursor in nonhuman primates.

Some CS authors rejected NS as based on circular reasoning or tautological error (table 2), that is, "survival of the fittest," with the fittest defined as those who survive. However, NS is not based on circular reasoning. The phrase "survival of the fittest" is a simplistic *description* of the theory of NS, not the *basis* of the theory of NS. The basis of the theory of NS is the pair of observations that heritable variation exists and that different variants have different chances of survival and reproduction. These observations are facts that have been documented<sup>77</sup> and do not relate to each other circularly.

One CS author who characterized NS as based on circular reasoning, applied circular reasoning of his own. His argument against NS that environmental pressure can create variation within "created kinds" but cannot produce new "kinds"<sup>78</sup> is circular, because "created kinds" are defined as having arisen by special creation and not by NS or by evolution.<sup>79</sup> Using the same circular argument, some CS authors who accepted the existence of directional selection within baramins stated that the resulting changes were not evolution, because no new "kinds"

were produced.<sup>80</sup> Such assertions demonstrate not only circular reasoning but also a difference in the use of the word "evolution" between CS authors and mainstream biologists. To the latter, heritable changes even within species fall under the umbrella of "evolution."<sup>81</sup>

#### NS within Baramins

Through both the twentieth and twenty-first centuries, while most CS authors have denied NS, others have insisted that NS occurs and that instances of it have been observed and recorded within baramins (figs. 1, 2; table 2). In particular, there has been wide acceptance among NS authors that stabilizing selection occurs (fig. 1; table 2) and prevents evolution by keeping organisms the same through the generations. One author even made the astute observation that artificial selection, which perpetuates lineages with traits that would be lethal in the wild, is the prevention of stabilizing selection, which would have occurred in the absence of human interference.<sup>82</sup>

Numerous CS authors accepted stabilizing selection while denying directional or sexual selection or the role of NS in biological diversification (table 2). To support denial of directional selection, one author argued that it would end all life on Earth, because eventually a superspecies would outcompete all the others and drive them to extinction, following which, competition within that species would eliminate all but one of its members, which would subsequently die.<sup>83</sup>

Other CS authors accepted a role of NS in diversification within baramins. Regarding plant diversification, one author said that

after the Flood the Creator may ... have allowed such processes as gene mutation, natural selection, and polyploidy to equip these plants further for their new roles of clothing the earth with its diverse network of nascent habitats.<sup>84</sup>

According to another author, directional selection by carnivory was probably necessary in the post-Flood world, to increase fitness in a harsh environment.<sup>85</sup> Other CS authors asserted that directional selection had been documented, citing the examples of antibacterial resistance in bacteria,<sup>86</sup> pesticide resistance in insects,<sup>87</sup> the favoring of the dark morph of the peppered moth (*Biston betularia*) during the Industrial Revolution,<sup>88</sup> and changes in the genome of HIV.<sup>89</sup> Mainstream scientists have recorded a plethora of other examples of observed and documented directional selection that appear to have gone unnoticed by CS authors. Some particularly showy cases involve observed morphological changes in microbes<sup>90</sup> and multicellular organisms<sup>91</sup> in response to selection pressure. The latter include instances in which new ecotypes have appeared in recent decades,92 sometimes with reproductive isolation that defines the new ecotype as a new species, according to the biological species concept. Other cases involve observed physiological changes<sup>93</sup> in response to selection pressure, or demonstrations from genetic studies that NS has recently occurred.94 Instances in which microbes have been observed to acquire endosymbiosis<sup>95</sup> or multicellularity<sup>96</sup> in the laboratory in response to selection pressure, provide support for the feasibility of such events in the past macroevolution of eukaryotes.

Of seven CS authors who took a position on the existence of sexual selection, three accepted its existence (table 2) and proffered it as a potential explanation of specific biological phenomena: the preference of female crickets for males with larger nuptial offerings,<sup>97</sup> differences in vocalizations between two closely related bat species,<sup>98</sup> and a recent increase in height among human males<sup>99</sup> (table 2). Four authors rejected sexual selection as an explanation for other specific phenomena (table 2), such as human schizophrenia and the peacock's tail, citing work by mainstream biologists that casts doubt on the role of sexual selection in those cases.

The author who tentatively attributed the human male height increase to sexual selection later rejected the existence of sexual selection in general (table 2), arguing that "natural selection would select against sexual selection. Mates who are choosy about their mates are less likely to mate, and less likely to pass on their traits to their offspring."100 Recent research indeed suggests that choosier females are likely to mate less often,<sup>101</sup> but it also shows that female choosiness is a plastic trait that is reduced when conditions would prevent mating by overly choosy females, as for example when there is low mate availability,<sup>102</sup> immanence of oocyte release,103 or other conditions that make it costly to delay mating;<sup>104</sup> this plasticity ensures that choosy genes do not prevent reproduction but instead get passed on. The same author also objected that "If sexual selection caused the development of the male beard ... why do women often

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prefer clean-shaven males?"<sup>105</sup> Inherent in that question is the assumption that women generally do prefer clean-shaven males, an assumption that recent research shows is unlikely.<sup>106</sup> Furthermore, rejection of the existence of sexual selection contradicts evidence from myriad examples in which sexual selection has been documented.<sup>107</sup>

Although some CS authors rejected NS as a contributor to biological diversity, others accepted that NS contributes to diversification within baramins. According to two authors, extinct hominid species may represent diversity generated by NS within the human baramin.<sup>108</sup> According to others, NS is responsible for diversity among modern humans<sup>109</sup> or within other baramins,<sup>110</sup> including the fossil horse series<sup>111</sup> and the ceratopsian dinosaur clade.<sup>112</sup>

### Convergent Evolution

Numerous CS authors dismissed convergent evolution as an invention by evolutionists to explain away similarities in unrelated organisms (table 2). Some authors attributed such similarities to common design and claimed them as evidence of a common Designer (table 2). Others used arguments with unsupported assumptions, for example,

Convergent evolution should be nearly impossible within the evolutionary paradigm, because no two environments remain the same for long periods to "evolve" similar structures in very different animals.<sup>113</sup>

Nonetheless, some authors recognized that within a given (alleged) baramin were organisms with similarities that must have arisen in parallel and not by inheritance from the (alleged) originally created ancestor. Examples include parallel mutations of eye color in different lineages of fruit flies,<sup>114</sup> parallel gene duplications in flies,115 parallel similarities in cytochrome b genes in turtles,<sup>116</sup> and various similarities between different species of the cat family.<sup>117</sup> Others noted that organisms in different (alleged) baramins had independently acquired similar characteristics and that this must be called convergent evolution. Examples include the independent acquisition of  $C_4$ physiology in sixteen plant families,<sup>118</sup> saber-tooth morphology in four mammal families,<sup>119</sup> similarities between elephant shrews and ruminants,<sup>120</sup> and similarities between Old and New World vultures.<sup>121</sup>

One author argued that "shared mistakes" in pseudogenes between humans and other primates were due to parallel molecular evolution rather than common ancestry.<sup>122</sup> Another argued that Homo erectus represented ancestral human morphology, that H. erectus populations in different areas had convergently evolved *H. sapiens* morphology, and that this was an example of a biological trajectory that had been programmed into genes at creation and which is evidence of common design.<sup>123</sup> Another author even tried to have it both ways, explaining that the similarities between the dinosaur Deinonychus and the early bird Archaeopteryx were due to convergent evolution, so as to cast doubt upon the evolution of birds from dinosaurs, while denying-in the same article-that convergent evolution exists.124

### Final Thoughts

CS authors deny macroevolution. It is therefore unsurprising that they consistently deny that NS contributed to macroevolutionary processes such as the evolution of prebiotic molecules, the advent of complex biological structures and systems, and the advent of sexual reproduction. They also consistently deny that NS has contributed to symbioses. However, CS authors cannot be said to have achieved consensus regarding other aspects of NS. Some CS authors deny the existence of NS in general, directional selection, sexual selection, convergent evolution, and/or a role for NS in biological diversification. Others accept that those phenomena and stabilizing selection exist-and in some cases have been observed-within "created kinds." It will be interesting to see whether CS authors achieve agreement on these topics in future decades, or whether disputation regarding these topics will continue to prevent consensus.

It is also important to note that for much of the twentieth century, the naysaying CS authors had a point. The explosion in documentation of directional selection, sexual selection, and the influence of NS on biological diversification is mostly a phenomenon of the most recent three decades. Therefore, in previous decades, deniers of these phenomena were correct in that there was minimal or no observational evidence for such phenomena. However, now that a plethora of instances of these phenomena have been observed and documented, there is no longer any excuse to deny them.

## Appendix 1:

## Falsification of Claims of Irreducible Complexity

The claim that a biological structure or system is irreducibly complex is falsified if forms intermediate between the structure/system and its simpler counterpart(s) exist (hence, are viable) in extant or fossil organisms, or if viable counterparts with missing components exist in extant or fossil organisms.

#### a. Flagella

The proteins that compose and operate bacterial flagella differ across taxa, with different proteins missing in different taxa, thus showing that bacterial flagella are not irreducibly complex.<sup>125</sup> A simpler counterpart with homologous proteins exists: the bacterial type III secretion system.<sup>126</sup>

Unlike prokaryotic flagella, eukaryotic flagella contain two-part (basal body and axoneme) skeletons of microtubules. The components of the basal body differ across taxa, with different components missing in different taxa,<sup>127</sup> demonstrating that eukaryotic flagella are not irreducibly complex. A simpler counterpart exists: the pole of the mitotic spindle, which appears to have given rise to the eukaryotic flagellum by elongation.<sup>128</sup>

#### b. The Shapes of Diatoms

Diatoms exhibit a continuous spectrum of morphology and therefore do not lack intermediate forms.<sup>129</sup> Aspects of diatom morphology are functionally significant<sup>130</sup> and therefore subject to NS.

#### c. Chemical Pathways in Photosynthesis

Among prokaryotes is a spectrum of complexity – from simple to complex – in the morphology and chemistry of photosynthetic housing structures, reaction centers, antennae, pigments, and electron transport chains.<sup>131</sup> Also, in extant prokaryotes, simpler counterparts to photosynthetic pathways exist: light-driven, ion-pumping systems that convert light into chemical energy but are not involved in carbon fixation.<sup>132</sup>

#### d. C<sub>4</sub> Chemistry

Numerous plant species exhibit photosynthetic physiology that is intermediate between the  $C_3$  and  $C_4$  types.<sup>133</sup>

#### e. The Flower

Fossil<sup>134</sup> and extant<sup>135</sup> plants are known that exhibit reproductive structures with morphology intermediate between gymnosperm strobilae and simple flowers.

## *f. Spathe and Spadix of Jack-in-the-pulpit* (Arisaema triphyllum)

A spectrum of morphology intermediate between unmodified bracts and bracts that are modified into a spathe exists among extant members of the family Araceae, to which the jack-in-the pulpit belongs.<sup>136</sup> Inflorescences with morphology intermediate between a simple branching pattern and a spadix are common among extant plants.<sup>137</sup>

#### g. Compound Eyes

A spectrum of complexity and morphology of ommatidia (the units of compound eyes) – from simple to complex, with numerous intermediate forms – is present across the phyla Mollusca, Annelida, and Arthropoda.<sup>138</sup> Intermediate numbers of ommatidia also exist in compound eyes of different species, with the number varying from one to several thousand.<sup>139</sup>

#### h. Jumping Spider Eyes

The anterior median eyes of jumping spiders possess a corneal lens, a multilayered retina, muscles that move the retina, ultraviolet photoreceptors, photoreceptors for colors that humans can see, a fovea, and an elongated shape.<sup>140</sup> However, all but the last two traits are present in other spiders.<sup>141</sup> Jumping spider eyes are therefore derivable from other spider eyes and are not too complex to have arisen from them by NS.

#### i. Spider Web Production and Complexity

Simpler precursor structures to spinnerets are known from early fossil arachnids.<sup>142</sup> A spectrum with numerous intermediate forms exists between the simplest and most complex webs of extant spiders.<sup>143</sup>

#### j. Millipede Defense Systems

A variety of defense systems are present in extant millipedes, and intermediate states abound.<sup>144</sup> Defensive rolling-up varies from the production of a

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#### Appendix 1: Falsification of Claims of Irreducible Complexity (cont'd)

sphere to a spiral, and the intermediate form (a planar disk) exists. Chemical defenses vary from none to multiple secreted compounds, and various intermediate numbers and combinations of compounds exist. Defensive spines vary in thickness, complexity of branching, and number of rows, and intermediate combinations of these traits exist.

#### k. Click Apparatus of Click Beetles

The apparatus that click beetles use to right themselves involves an enlarged muscle and a pegand-notch arrangement on two exoskeletal plates.<sup>145</sup> The bodies of most other insects possess the homologous muscle and the homologous exoskeletal plates and therefore possess counterparts with missing components (muscle enlargement and a peg-andnotch shape).

## *I. Large Difference between Larval and Adult Dragonflies*

The morphological difference between larva and adult in insects varies from almost none to extreme, with numerous intermediate magnitudes present—and therefore viable—in various species.<sup>146</sup>

#### m. Food-Catching Basket of Dragonflies

The dragonfly's food-catching basket is simply the first four legs. They are generic insect legs that lack the specializations present in other insects.<sup>147</sup> Other than their close spacing,<sup>148</sup> there is nothing particularly remarkable about them, and they are no more complex than the legs of other insects.

#### n. Cephalopod Eyes

A nearly continuous spectrum, with numerous intermediate forms, exists between the simplest molluscan photoreceptors and cephalopod eyes.<sup>149</sup>

#### o. Killer T-cell System

A comparison of protochordates, jawless fishes, jawed fishes, and tetrapods reveals a spectrum of complexity within the immune system and within its T-cell system. Fishes exhibit states intermediate between those of protochordates and tetrapods.<sup>150</sup>

## *p. Eyes of Humans, Other Tetrapods, and Fishes*

A nearly continuous morphological series links the simple photoreceptors of protochordates to human eyes via the extant diversity<sup>151</sup> within mammals, non-

mammalian tetrapods, jawed fishes, jawless fishes, and recently discovered fossils that fill in morphological gaps between fish groups<sup>152</sup> and between protochordates and jawless fishes.<sup>153</sup>

#### q. Giraffe Neck

Fossil members of the giraffe family exhibit a spectrum of neck lengths and vertebral morphology intermediate between those of short-necked ungulates and extant giraffes.<sup>154</sup>

#### r. Avian Respiratory System

Recent research shows that various extant reptiles have respiratory systems that, in morphology and airflow, are intermediate between simple lungs with bidirectional flow and the complex, avian system of unidirectional flow-through lungs-plus-air-sacs.<sup>155</sup>

#### s. The Feather

Fossil precursors of avian feathers exhibit a spectrum of morphologies intermediate between a simple filament and a primary flight feather.<sup>156</sup> Despite the erroneous claim that the simpler fossil "protofeathers" are actually degraded collagen fibers from within the dermis,<sup>157</sup> new research demonstrates that they contain melanosomes, the pigment-bearing organelles in the cells of feathers.<sup>158</sup>

#### t. The Human Musculoskeletal System

A long and detailed fossil series of intermediate forms shows the derivation of the location and arrangement of human muscle attachment sites from those of early tetrapods, via fossils of early amniotes, early synapsids, early mammals, and early primates.<sup>159</sup>

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# Етніся

**CREATION ETHICS: Reproduction, Genetics, and Quality of Life** by David DeGrazia. New York: Oxford University Press, 2014. 234 pages. Paperback; \$26.95. ISBN: 9780190232443.

*Creation Ethics* provides a broad perspective on the challenging topics of reproduction, genetics, and the quality of life. The author, David DeGrazia, carefully inspects various viewpoints on controversial reproduction issues, such as prenatal moral status, along with the implications these conclusions pose. Throughout the text, he remains open to examining a variety of views on the topics, and provides his own perspective on these issues, often incorporating arguments from multiple perspectives.

After an introduction, chapter two presents the author's tripartite framework, from which he argues in favor of abortion and embryonic research. The first point in his argument is the biological view of human identity. DeGrazia claims that human persons come into existence when the organism is born, and their identity remains throughout their lifetime. He discusses other points at which arguments are made for the beginning of human personhood, such as conception, the 16-cell stage, and two weeks post-gestation. The second part of his framework questions sentience, or the ability to perceive feelings. DeGrazia states that the potential for sentience is enough for someone to have moral status, and argues that this begins in the third trimester. The third part of his framework is the TRIA (Time Relative Interest Account), which states that when looking at the harm from death, one should evaluate the value of the future life along with the psychological connection of the one who dies with the possibility of their future. He therefore maintains his support of abortion and embryonic research by arguing that death would not be a great harm to a fetus, because it does not have psychological connection with their future.

Chapter three focuses on human identity and human nature in the context of genetic enhancement. After genetic enhancements, a person's narrative identity (how they characterize themselves) might change, but their numeric identity (their quantitative person) will not. The chapter concludes by asking what risks genetic enhancements could have on humanity. He notes that, at the extreme, genetic enhancement could create a group of people so advanced they would either enslave or obliterate the unenhanced human population. He argues there is nothing inherently wrong with advancements that could eventually surpass humanity; nonetheless, there should be moderate regulation of genetic enhancements.

Chapter four looks at the challenge of reprogenetics which involves using reproductive and genetic technologies to modify and select embryos for enhancement (p. 96). There are three primary types of interventions on fetuses, embryos, and gametes: prenatal genetic diagnosis (PGD), prenatal genetic therapy (PGT), and prenatal genetic enhancement (PGE) (p. 96). One of the main arguments against PGE is that genetic enhancements could change a person's genome so significantly that they are no longer the same numeric person. To counter this, DeGrazia presents a Robustness Thesis that claims that once someone comes into existence that person will always be numerically the same. Nevertheless, he does believe genetic enhancements could promote stereotypes, and therefore government funding should not be allotted for such research.

Chapter five addresses the question of whether it "wrongs someone to bring him into existence and, if so, how can we coherently explain the nature of the wrong" (p. 139). DeGrazia presents the claim that in standard wrongful life cases, such as completely debilitating disabilities, procreation is wrong. In cases with imposition of harm, procreation is strongly wrong. However, in cases with simply exposure to harm, procreation is weakly wrong (p. 155). Through this description, he makes the important distinction between imposing harm and exposing a child to harm.

DeGrazia opens chapter six with the difficult question of what parents owe their children. He determines parents owe their children a life worth living, one in which their basic needs are met. He applies this to having children who parents know will have disabilities. He examines three situations: (1) same-individual choices wherein the parent has a child with disabilities or has the same child without disability, (2) differentnumber choices in which a child will be born with a disadvantage, or not born at all, and (3) same-number choices which leads to the nonidentity problem where parents could have a child with disability, or they could choose to abort or delay conception and have a different child (p. 164). To address the nonidentity challenge, DeGrazia notes that it is important to disregard the notion that every form of wrongdoing harms someone. In these situations, he states, there are many cases of victimless harm.

The final chapter of the book asks what obligations we have to future generations. DeGrazia concludes that our obligations to future generations are based on justice, and we should not think of the interests of

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future generations as less important than our current interests, just because of temporal distance.

DeGrazia does not shy away from addressing difficult issues in this book. His arguments are clear and well supported. I appreciated that DeGrazia addresses arguments from opposing views, noting both their strengths and their weaknesses. This approach makes the book accessible to readers who do not agree with all of his conclusions. Many of the arguments presented throughout Creation Ethics lead to implications about what Christians believe on the highly emotional issues of abortion, embryonic research, and genetic modification. DeGrazia argues that abortion should be allowed, but also cedes, saying, "I believe that a broadly pro-life approach remains standing as a reasonable option" (p. 43). Therefore, pro-life or pro-choice Christians can read DeGrazia's book and find some arguments that will resonate with either perspective.

DeGrazia's writing style is heavily laden with philosophical and scientific terminology that readers need to be prepared to encounter. I would recommend this book to someone who is interested in learning more about philosophical questions of reproduction and who is familiar with or interested in learning more about reproductive technologies and philosophical arguments.

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**DEBATING DARWIN** by Robert J. Richards and Michael Ruse. Chicago, IL: The University of Chicago Press, 2016. xvi + 267 pages, including bibliography, index, and 21 figures. Hardcover; \$30.00. ISBN: 9780226384429.

The "debate" of the title of *Debating Darwin* is both intriguing and an enticement. What is the meaning of this brief title? The debate at hand is over the character of Darwin's intentions, argumentation, and self-understanding as a natural historian. The debate is prosecuted by Michael Ruse, who situates Darwin within the world of British empiricism, Paleyan Natural Theology, and nineteenth-century social progressivism, and by Robert J. Richards, who constructs a case for Darwin as an intellect profoundly influenced by continental European Romanticism and *Naturphilosophie*.

The formal schema of the book is indeed that of a debate. After a short introduction, Michael Ruse presents Darwin as a consummate nineteenth-century

Briton (80 pp.). Next, Robert J. Richards documents the extensive influences of the Continent on Darwin the explorer and theory builder (67 pp.). Each then provides a reply to the other (25 pp. each). Finally, a joint Epilogue outlines the central areas of agreement and contention (30 pp.). The engagement is cordial, but unyielding.

Both authors rely on their respective multi-decadal, focused examination of nineteenth-century evolutionary science. Extensive notes provide introductions to their previous work as well as to that of other scholars. Both back their claims with relevant quotes from Darwin's correspondence, notebooks, diaries, and autobiography.

One of the beneficial results of the tight format of the initial chapters is the composition of a tidy and eminently readable short biography of Darwin. In order to build their respective cases, Ruse and Richards examine Darwin's family background, education, reading, scientific friends and correspondents, and expressed opinions. Of particular significance are Darwin's own statements regarding what he felt he had accomplished and what he felt others had missed in his arguments. The bifocal format yields a stereoscopic view of Darwin the scientist. I highly recommend this book if for no other reason than its utility as a concise Darwin biography.

But there is more. For one, we are introduced to the broader cast of characters who influenced Darwin. Ruse invokes William Paley, William Whewell, John Herschel, Charles Lyell, and (distantly) Adam Smith, among others. Richards points toward Alexander von Humboldt, as well as the German morphological systematization typified by Goethe and Carus and their English spokesman, Richard Owen. Alfred Russel Wallace is not neglected by either of our debaters.

Several conceptual issues yet besetting biological evolutionary theory were initially addressed by Darwin, Wallace, and their immediate successors. What is (are) the unit(s) under selection? To what extent are teleological explanations permitted for a science of organisms? Does the history of life demonstrate some sort of progress? To what degree are human sociality and religion influenced by our biological substrate and deep-time history? What is the role of chance in natural systems? In what sense does the discipline of evolutionary biology carry forward the atomisticmechanistic program for the physical sciences begun in the seventeenth century? Does this mechanistic program really render God "irrelevant" (cf. Ruse, in his "reply to Richards," p. 178)? The authors outline the outworking of these problematic issues for our present situation, especially in the Epilogue. In the

process, they introduce the makers of the neo-Darwinian synthesis and their accomplishments. New arguments surrounding group selection and sociobiology are summarized.

The last two sections of the Epilogue address the phenomena of (1) human consciousness and (2) religion and God. The penultimate section argues for an (evolutionary) emergentist origin of mind; it includes a rebuttal of some of the claims of epiphenomenalists such as Daniel Dennett, as well as a counterbalancing critique of Thomas Nagel's attack on evolution as insufficient to explain the origin of consciousness.

The final section includes an examination of the arguments of Jerry Coyne to the effect that evolution precludes theism. Prominent Christian evolutionists such as Kenneth Miller and Simon Conway Morris are acknowledged. The authors demonstrate that Coyne's logic is overextended; they identify and rebut examples of *ad hominem* attacks on religion as well as argumentation by fiat. During this discussion, Stephen Jay Gould's proposed resolution for the science-religion conflict, that of "non-overlapping magisteria" (NOMA), is introduced but rejected as too simplistic: "Coyne doesn't mention it, but from the science side, values flow across any proposed boundary; that is, science itself is grounded in values" (p. 228).

The authors invoke Friedrich Schleiermacher to describe Coyne, Richard Dawkins, and others as contemporary "cultured despisers of religion." They urge the adoption of a more intuitive sense of awe in the face of the cosmos, a sense which naturally undergirds a scientific curiosity. Ruse and Richard ably demonstrate that Darwin, while far from a devout theist, could not shake the sense that some agency lay behind the universe.

This is not Gould's doctrine of separate magisteria, rather this view of religion is not merely compatible with science, it is necessary for the advancement of science. And, perhaps, for leading a coherent life, one in which the appreciation of poetry, art and religion provide the same kind of experience that leads creative scientists to advance beyond their more pedestrian colleagues. Darwin was one such as these. (p. 233)

Darwin gets the last word here, and that is as it should be given the logic and flow of the volume. Darwin's theology, thin as it is, will not be attractive to either contemporary atheists or robust theists; that discussion best resides in a different venue. *Debating Darwin* is well organized, insightful, and informal. It succeeds as a concise introduction to Darwin the scientist and human being, as well as to his contemporaries and successors. An enjoyable read and an edifying one, useful to many different audiences.

Reviewed by Ralph Stearley, Professor of Geology, Calvin College, Grand Rapids, MI 49546.



FASHION, FAITH, AND FANTASY IN THE NEW PHYSICS OF THE UNIVERSE by Roger Penrose. Princeton, NJ: Princeton University Press, 2016. 520 pages. Hardcover; \$29.95. ISBN: 9780691178530.

Eminent mathematical physicist Roger Penrose continues to indulge his prolific writing habit, offering us yet another popular work with an irresistible title. *Fashion, Faith, and Fantasy in the New Physics of the Universe* is his latest attempt to explain the challenges and prospects of twenty-first-century theoretical physics. The book's title appeals to a popular-level readership, and it is sure to end up on the shelves of many aspiring and ambitious readers. However, this is not light reading, and even those with an extensive physics background will find this volume a challenging read. Even so, there are valuable perspectives given by Penrose that only someone of his stature in the physics community can offer, and that should be taken seriously.

The book is divided into four lengthy chapters, each about 100 pages of a nearly self-contained treatise on a subject. The first chapter, Fashion, is about the development of string theory, the most fashionable theory amongst practicing theoretical physicists with its promise of providing a mathematical scheme of unifying all four fundamental forces of nature. Criticisms of string theory have focused on its grand claims of numerous unseen dimensions and a possible glut of unseen universes, while offering virtually no firm testable predictions. However, Penrose is a gracious critic, and points out many intriguing ideas that have come out of string theory, including some surprising advances in mathematics. Indeed, mathematical elegance has served as the guiding principle, in lieu of experimental data.

Penrose guides the reader through the theoretical challenges that motivated string theory in the first place: a desire to find a unique unifying scheme that brings quantum field theory (QFT) into consistency with universal gravity, which already has a very successful classical treatment in Einstein's general relativity. The common wisdom is that gravity must be properly quantized to be compatible with QFT. Faced with perplexing divergences that arise in normal

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QFT when particles are treated as objects occupying singular points in space, string theory finds a clever way to avoid those, if all particles really are tiny 1-D strings vibrating in higher dimensional space. Further coupled with supersymmetry, which proposes a correspondence between half-integer spin particles called "fermions" and integer spin particles called "bosons," string theory proposes to solve several theoretical problems. However, supersymmetric particles have not yet been observed. In addition, the mathematical consistency is not clear-a troubling issue that Penrose believes has been ignored in the excitement over string theory. He argues that the excessive functional freedom from the higher dimensions has not been properly addressed. Singularity theorems from Penrose and Hawking in general relativity appear to imply instability of the highly curved extra dimensions posited by string theory.

Disturbingly, rather than finding a unique unifying scheme, theorists found that there were several different viable types of string theories. Connections found between them led to M-theory, suggesting vibrating "branes" of more than 1-D. Intriguingly, ideas such as AdS/CFT correspondence led to applications in diverse areas of physics, ranging from condensed matter to black holes to cosmology. Yet the most perplexing turn in string theory came when it was found that different starting vacuum states lead to completely different universes, as many as 10<sup>500</sup>, and thus a "landscape" of universes. Are these "real" or merely mathematical? The conclusion reached by some physicists is that, out of the multitude of existing universes, we just happen to occupy an improbable one that is life friendly-a rather sad version of the anthropic principle. Penrose poignantly points out the irony in this sorry state of string theory. Must string theory really throw away the goal of finding a unique description of nature and conclude that there is no such unique description? This is a strange departure from its initial motivation, and Penrose finds this unacceptable.

In chapter 2, "Faith, an Overview of Quantum Theory," Penrose begins to point out where he believes the problem lies. The overwhelming success of quantum theory in modeling the behavior of matter is unquestioned. This is precisely the point that Penrose believes should be reviewed. Quantum theory leads to some rather troubling views of reality, including the apparent nonlocality of how entangled states behave. Entangled states imply that a particle is simultaneously in more than one state and connected in an overall state to another particle, such that a measurement made on one immediately forces the other into a certain state, no matter how far apart they are separated. The EPR effect, named after Einstein, Podolsky, and Rosen, has now been observed in the entanglement of particles separated by up to 143 km. This cannot be reconciled with any kind of classical explanation, and thus represents a further triumph in the utility of quantum theory. However, the concept of entanglement leads to some very troubling implications including not only the eerie aspect of nonlocality, but also what is considered "real" or merely a convenient calculational tool.

The Copenhagen interpretation of quantum mechanics does not assign any kind of ontological reality to the wave function of a particle, treating it only as a calculational tool for giving us probabilities, which are in spectacular agreement with "real" measurements. Accordingly, there is no real sudden "jump" from a calculated quantum state to a measured state. It is merely viewed as a shift in our knowledge of the state. However, Penrose questions this view, pointing out that a reality can and should be argued for the quantum state itself. Penrose argues that the connection between quantum states and measured states lies in a better understanding of the reduction measurement itself. The resolution Penrose offers is that gravity limits the extent of quantum superposition. A gravitational self-energy arises when considering two different locations for a massive particle. Penrose explains how this forces instability in any quantum superposition, collapsing it into one state. Thus, rather than forcing general relativity to conform to an unquestioned quantum theory, it is quantum theory that should be treated in a more limited sense. Experimental tests on the limits of entanglement may soon extend to larger mass displacements, allowing an important test on the limits of our quantum "faith."

Chapter 3, Fantasy, describes modern cosmology. The standard Big Bang model has achieved remarkable success in accurately describing an expanding universe filled with ordinary matter, dark matter, and dark energy. Success in predicting the cosmic microwave background radiation (CMBR), discovered in 1965, and its tiny fluctuations in temperature, discovered first in 1992 and more recently refined in its precision, is nothing short of fantastical. Penrose describes the theoretical developments of the Friedmann-Lemaître-Robertson-Walker (FLRW) model of cosmology, founded on Einstein's general relativity. The successes of inflationary theory in explaining special features of our universe are discussed. However, the FLRW cosmological model represents a unique condition of homogeneity and isotropy that present theoretical physics ideas do not explain.

The Second Law of Thermodynamics implies that the entropy of the universe is much greater today than in its infancy, when it exhibited an exquisite order. The apparent contradiction of the thermodynamically smooth CMBR temperature, a highly entropic state achieved long before the moment of decoupling at 380,000 years after the big bang, is reconciled with the Second Law by comparing it to the exceedingly vaster entropy of today's universe, filled with black holes. The problem is not the Second Law, but rather the explanation of why the universe exhibited such extreme order in its infancy, with no degrees of gravitational freedom perturbed. Appeals to the anthropic principle, that this universe was simply selected out of a large landscape of universes, strike Penrose as rather unconvincing. Penrose responds:

It is, to my mind, disturbing how frequently theoretical physicists eventually come to rely on such arguments in order to compensate for a lack of predictive power that their various theories turn out to have. (p. 322)

Penrose is critical of theorists, not for offering fantastical ideas to explain the special features of our universe, but because, at present, they are not fantastical enough. New ideas are needed.

Penrose concludes his book with a chapter on his own favored theoretical approach, "twistor" theory, an approach he first proposed in 1967. Twistor theory attempts to unite quantum theory with a relativistic space-time physics in an abstract twistor space that renders space-time itself a secondary notion. The power of complex analysis is utilized in the twistor space computations. The theory is definitely the domain of mathematical physics. However, in contrast to string theory, it does not propose any space-time dimensions beyond our observed four dimensions.

The mysterious quantum features that Penrose claims can be explained with twistor theory include nonlocality and quantum state reduction. Nonlocality arises naturally in the formalism of twistor theory. It explains all quantum state reductions as gravitational effects, forcing superpositions of states to decay into measurably "real" states. Penrose calls the latter "objective reduction" (OR). The premise of Penrose is that quantum theory must be limited in its domain. However, problems in using twistor theory include aspects of cohomology and the "googly" problem, areas in which Penrose believes progress is being made. As for problems in cosmology, Penrose proposes a conformally cyclic version with pre-big-bang world-lines connecting to post-big-bang world-lines, so that a Weyl curvature hypothesis can be employed. The latter is an attempt to explain the special FLRW condition of standard big bang cosmology, even without a period of inflation.

Penrose's book takes the reader on an extensive journey that summarizes much of Penrose's life work. Unless the reader has extensive prior knowledge of mathematical physics, it will be difficult to grasp many of the technical points made. Penrose provides a 70-page mathematical appendix to help nontechnical readers, but it appears to be of very limited utility unless one already has familiarity. It might have been better for Penrose to attempt a much more lay-readerfriendly book, focusing primarily on the key aspects in which modern physics has struggled, but thus far has fallen short of satisfactory answers. Indeed, hidden between technical sections are excellent discussions that provide a compelling case that we have not yet arrived at satisfying answers to many of the deepest questions raised in modern physics. As for making a good case for the viability of twistor theory, this reader remains unconvinced. I am much more persuaded that he loves conformal mathematics.

Finally, what kind of connection can a Christian find between the frontiers of theoretical physics and faith? Penrose is restricted to faith in the unquestioned truth of quantum theory, not compared favorably to a religious faith, which Penrose relegates to mostly unchanged messages dating back thousands of years. Is our Christian faith a stagnant one, unchanged by time or advances in science? Granted, the central message of Christianity, the substitutionary atonement offered to believers by the life, death, and resurrection of Christ, will not be altered by advances in science. However, modern science continues to raise important questions not readily answered in scientific terms. As argued by Penrose, appeals to an anthropic principle as an explanatory tool simply reveal the lack of a fully satisfactory explanation. What modern physics has revealed includes the elegance, the order, the symmetries, and the precision we observe in this universe, all of which are highly compatible with the Christian faith in a Creator of unfathomable wisdom.

Reviewed by Steven Ball, Professor of Physics, LeTourneau University, Longview, TX 75607.

## **Recently Published Works**

Along with all their other contributions, many members of ASA and CSCA publish important works. As space permits, *PSCF* plans to list recently published books and peer-reviewed articles related to the intersection of science and Christian faith that are written by our members and brought to our attention. For us to consider such works, please write to patrick.franklin @prov.ca.

## **Book Reviews**



THINKING FAIR: Rules for Reason in Science and Religion by Lucas John Mix. North Charleston, SC: CreateSpace Publishing, 2016. 302 pages. Paperback; \$19.99. ISBN: 9781515153283.

In this thoughtful probing of the way we think and reason, Lucas Mix challenges us to be aware of how and why we hold the beliefs that we have. He shows how the path to knowledge in science differs from that in religion and that both are necessary in our worldview that guides our behavior.

Lucas Mix is well qualified to speak about both science and religion. He holds a PhD in organismic and evolutionary biology from Harvard University and carried out a postdoctoral project at Harvard in theoretical biology considering the history of the definitions of life. He also holds an MDiv from the Church Divinity School of the Pacific and is an ordained priest. He is a member of the Society of Ordained Scientists and is part of the Anglican community.

After an introductory chapter, the remaining twenty chapters are organized in four sections: Reason; Science; Religion; and Change. Mix is interested in what we think, what we do, and with whom we do it. We need to understand why people think what they do and how this affects their actions. He has no intention of persuading us what to think or even how to think. Rather, in his own words, he intends to "present this as an exercise in thinking broadly, sympathetically, and systematically about how you view the world. I want you to experience different ways of thinking and reflect on what it would mean to do them well" (p. 7).

The three chapters in the section on Reason lay out the basic tools and terminology for considering how we think. The way in which we perceive reality and correlate it with our experience comprises the logic and reason that we use. We utilize a set of axioms and logic in our reasoning. Deduction, induction, observation, and authority are the primary ways of reasoning for finding new knowledge. For Mix, "Rationality comes from thinking clearly, transparently, systematically, and carefully" (p. 42). His goal is to encourage us to recognize our own style of reasoning and to learn to understand and appreciate the way other people think.

Chapters 5–10 delve into science and the way in which we acquire knowledge through what we call the scientific method. Four key principles of the scientific method are discussed: Mutual observables; symmetry; hypotheses; and iteration. Applying these principles in practice takes various forms and relies on a variety of factors that help us gain confidence in an explanation. Scientific aesthetics is one of those criteria, including simplicity, utility, fruitfulness, and coherence and consistency. Finally, he discusses the basic concepts of reductionism, emergence, ontological physicalism, and methodological physicalism.

Through all these principles of thinking, science offers us a way to develop a model of reality. As we compare this model with reality, we encounter phenomena that either reinforce that model or else compel us to reassess our model. Learning centers on the way in which we respond to that comparison and how we compare our understanding with that of others. Above all, Mix points out that the scientific method fails to provide us with all the knowledge we need to make decisions and take action. That leads us to the section on religion, to which he devotes six chapters.

Whereas science provides what Mix calls a transparent, effective epistemology that informs us about our world, it does not provide guidance for ideas, choices, and values. For Mix, "religion has to do with propositions about order and value, how we generate them, and how we react and respond to them. Ontology and epistemology fall out of religion, almost by necessity" (p. 120). Mix emphasizes his view of knowledge and belief. Knowledge is a statement for which we have some evidence that it is true. Belief is conviction with consequences, knowledge that changes our behavior. With this perspective, science is not the sole domain for knowledge nor is religion the sole purveyor of belief. Our worldview needs a broader view than what either science or religion alone can provide.

After devoting a few chapters on common issues such as miracles, determinism vs. free will, revelation, and the existence of the soul, Mix turns to what he sees as the three basic aspects of religion: philosophy, practice, and politics. Philosophy deals with "right thought," referring to orthodoxy and the creeds commonly associated with religion. Practice deals with "right behavior," the norms of activity and rituals that characterize religions. Politics refers to "right relationships," our participation in the community and our social interactions. Religion is therefore a necessary complement to science in helping us with our values, choices, and actions.

The final section of four chapters is titled Change. Here we arrive at the challenge that Mix has for us. We all have a model of the cosmos and that model might not match the reality that we encounter. When we understand why we think the way we do and why others think otherwise, we are better able to respond to that dissonance. Scientific knowledge leads to models that enable power when they accurately reflect the way nature works. Religious knowledge and beliefs lead to values that help us decide how to use that power. The critical feedback loop of belief shaping behavior and behavior shaping belief depends on our awareness of our ways of thinking. "Above all," Mix concludes, "I want you to have greater control over your own ability to grow conviction. I want the change to be in your hands" (p. 271).

It is refreshing to read a book that does not seek to persuade or to argue for a particular idea. The ratio of question marks to periods is remarkably high, almost reflective of a study guide. The questions are designed to be internalized and to become an autonomic way of thinking for us.

I found the book easy to read and comprehend. It made me realize how little attention I had paid to considering the way I think and the reasons for my reasoning. The thrust of the book might be called "Philosophy Made Practical" with a focus on science and religion, though it is much more broadly applicable. Mix does not introduce new philosophical ideas and has selected only those aspects that he feels are most relevant to us. He is clear about his Anglican faith and why he finds it to be a valued part of his way of reasoning. Yet he respects other religions with their perspectives. He challenged me to recognize that philosophy is not a specialty reserved for experts, but a necessary part of our lives. I need to learn to incorporate this self-awareness of my thinking into my way of life.

If all authors and speakers on science and religion would not only read this book but adopt the reflective style he suggests, the conflicts would be greatly diminished. I highly recommend it to all who are interested in philosophy, epistemology, and their role in science and religion.

Reviewed by Randy Isaac, ASA Executive Director Emeritus, Topsfield, MA 01983.



**NETWORKED THEOLOGY: Negotiating Faith in Digital Culture** by Heidi A. Campbell and Stephen Garner. Grand Rapids, MI: Baker Academic, 2016. 192 pages, including endnotes and index. Paperback; \$22.99. ISBN: 9780801049149.

Christian communities have always shaped and been shaped by changes in media technology. Secondcentury Christians were early adopters of the codex, bound books as opposed to scrolls. This in turn prompted the development of the canon (from a human viewpoint) and consequently shaped the ecclesiastical authority structure and distinction between orthodoxy and heresy. Centuries later the printing press made possible the rapid promulgation of ideas that emerged during the Reformation but also, it has been argued, led to more standardization of liturgy and hymns and prayers.

The contemporary church is enjoined to give a thoughtful response to modern media and the technology that supports it. Today's digitized, transcoded, and mashable media content changes the way we think about text and other information. Social media and other online social interaction change the way we think about friendships and communities. Virtual worlds and augmented reality change the way we think about presence. All of these have implications for how the church sees itself and practices its mission.

Christians are far from having a united response. One chapel speaker at Wheaton College (where I teach) began by asking students to open the Bible apps on their cell phones. The chaplain at Covenant College, on the other hand, has banned electronic devices from chapel; students should bring God's word in a good old codex. What does one value more, reaching techsaturated millennials at their level, or eliminating the distractions from communal worship in a physical, real-time setting?

In *Networked Theology*, Heidi Campbell and Stephen Garner seek to "map out a framework for identifying an authentic theology" that accounts for new media and digital culture and equips the church to reflect and respond appropriately. Campbell is a communications professor and Garner is a theologian. Together, though drawing especially from Campbell's prior work, they bring a well-informed perspective on the intersection of media studies and theology. The book provides context (historical, technical, and theological) to questions new media raise for religious communities and provides discussion points that some communities may find helpful.

The authors spend the first few chapters surveying the background. They highlight the church's response to media and technology throughout its history but especially summarize the contributions of Jacques Ellul and Ian Barbour in the recent century. Some Christians have responded to various new waves of tech with optimism about how they improve lives and empower ministry. Others are more skeptical, mindful of the cultural cost and the people who are marginalized. Still other faith communities have developed a more nuanced view of the social context of technologies. The authors also give an introduction

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to the vocabulary and concepts of new media theory, describing some of the key attributes that distinguish "new" media from old and the differences between Web 1.0, Web 2.0, and its successors (think of the progression from static web pages to wikis and social networks and then to cloud applications). New media theory provides an articulation of how a networked society affects life: the authors identify terms such as "remix culture" (media products are never final cuts) and "publicized privacy" (both voluntarily through Pinterest and involuntarily through surveillance technology). Not being a media person or even that much of a tech person (I'm a computer scientist, but with more affinity to the M of STEM than the T), I found this summary helpful.

The authors' core contribution is in their identification of the dimensions of church life that are affected by media and technology, and in encouraging churches to contemplate appropriate questions. In ages past, membership in a community like a church was rooted in shared rituals, whereas life online fosters communities built on shared interest. At one time religious identities tended to be fixed, but now network technology enables a more malleable identity whose religious practices can be as varied (and unrelated) as one's YouTube posts. Media technology has implications for the nature of leadership: as with authority structures in other settings, new technology can be either threat or tool.

Despite the technological novelties, the authors point out that the key questions endure: "'What must I do to inherit eternal life?' has not changed, but the sociocultural context that shapes how those questions are asked and answered has" (p. 81). In light of their lives lived online, the authors guide believers in asking a series of questions: Who is my neighbor? Where is my neighbor? How should I treat my neighbor?

Campbell and Garner recommend a four-part strategy for a religious community to reflect on networked living. They should be aware of their own history and the precedent of their earlier relationship with mass media. Many Amish communities, for example, do not ban cellphones outright but consider them communal property, just as they have treated landlines. Second, communities should let their core beliefs inform their media values. The authors speculate that churches with a highly liturgical heritage will not find virtual-world sacraments acceptable. The third angle is what they call "media negotiation," in which communities apply core beliefs to evaluating whether specific media applications complement or contradict those beliefs, balancing a technology's usefulness against problematic features it may have. Finally the authors advocate community discourse, noting that

how one talks about technology is itself an expression of religious identity.

The authors do well to encourage the church both to make good use of new media and to be vigilant against unintended consequences. They write,

You may help set up a social media group for your church's youth program ... A good question to ask when doing that is not only who will this include but also what potential does this have for marginalizing some of those you are trying to support? While a social media group may be a good way to connect with the young people in this group, some may be left out because they are too young to legally have an account on the social media platform chosen or their parents or caregivers will not allow it. (pp. 130-31)

On a wider scale, the authors warn the church against neglecting the "information poor." (Concerns about the "digital divide," though real, should be kept in perspective. In 2013 the UN estimated that while one billion people lack mobile phones, two and a half billion lack toilets.)

On the other hand, not all believers will find all of Campbell and Garner's methods useful. They describe the church's reflection on media as part of "public theology," which they define (quoting Duncan Forrester) as theology that "seeks the welfare of the city before protecting the interests of the Church, or its proper liberty to preach the Gospel and celebrate the sacraments." In their own words, "the world sets the agenda for a public theology." Some Christians will question whether it is ever the church's business to pursue social justice in this world independently of its mission to preach the good news of salvation.

I found the authors a bit fond of trendy terms – there's much about frameworks and things that are situated or need to be negotiated. But the overall style is competent and readable, and the authors fit a surprisingly large number of ideas into 147 pages. Although the examples were drawn mainly from the Englishspeaking world, the book is refreshingly not centered on North America (Garner is a Kiwi and Campbell is UK-educated).

The authors may have overstated their claim that their "networked theology" offers a distinct approach to these questions. When confronted with a novelty, it is often best to identify continuity with the familiar. This book is at its best when it encourages believers to see life online as just another context in which we are called to act justly, love mercy, and walk humbly with our God.

Reviewed by Thomas VanDrunen, Associate Professor of Computer Science, Wheaton College, Wheaton, IL 60187-5501.

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