PERSPECTIVES on Science and Christian Faith

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In This Issue …

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

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Perspectives on Science and Christian Faith

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Science and Scientism

James C. Peterson

Justin Barrett begins this issue with an introduction to the developing field of cognitive science and some of the insights and questions it may raise for Christian faith. In the next article, Robert Sears focuses, in particular, on what cognitive science says about how we know what we know, influenced by both religious experience and social interpretation. At the center of cognitive science lies the fact that humans look for agency. This is an important defense for survival that seems to be built into us from genes to brain. If one is living in a potentially hostile territory and sees a set of stones in a creek, spaced just about right to walk across, one would do well to consider if someone placed them there. That thought alerts the perceptive to watch for friend or foe. Just as innate for human beings is to imagine how other minds are thinking. Such is essential to the understanding and cooperation of a social world that is crucial to human survival. This skill is often called a theory of mind. Human beings have, built in, these two important interests and skills: agency detection and theory of mind. When these skills reinforce each other, humans creatively suppose gods from the Roman pantheon of Zeus and Apollo to the Nordic gods of Odin, Thor, and Freya. Some cognitive scientists then claim yet a further step, that such conjunction disproves any perception of God.

The parallel conjunction of built-in interest and ability is found in the way we learn language: language that we social creatures need to survive. We have the genetically designed brain to seek patterns in sound and to interpret them as the expression of ideas. All human beings have these two predilections and skills that enable us to seek and recognize the language of others. Combining them, can we create a language of our own? Early on, my twin daughters did. But can we also recognize the existing language of others to communicate and build relationships? Yes, and we should.

Cognitive science traces out an interesting story of how these vital abilities may have developed. However, determining whether what they may be perceiving is real, is beyond the discernment of cognitive science as a discipline. The ability to imagine a new language does not mean that every experience of language is imaginary. The ability to imagine creatively the presence of another, and to theorize how that person may be thinking, does not mean that every encounter of another, and every attempt to understand them, is an imaginary construction. Cognitive science may well trace the development of capabilities that enable us to recognize and to be in right relationship with the one God revealed in Jesus Christ. This does not mean that it excludes the reality of the God who was and is and is to come. The distinction here is another instance of the difference between science and scientism. Science is most insightful and useful if it is practiced with the modest recognition of both what it achieves, and just as important, what it does not.

In our next article, Philip Senter and Jared Mackey log the increasing tension in the publications of the Creation Research Society between acknowledging genetic degeneration and still resisting the recognition of vestigial structures. Sy Garte then considers whether the evolution that we observe must be as purposeless as is often assumed.

The book review section includes a critical review of a book by Patrick Franklin, who is in charge of our *PSCF* book review section. It is titled *Being Human, Being Church: The Significance of Theological Anthropology for Ecclesiology*. While Franklin would have been scrupulously objective in passing on the reviewer's critique, this review was neither commissioned nor edited by Franklin. Without Franklin's involvement, the reviewer has much that is positive to say about the book. A hearty congratulations and appreciation to Patrick Franklin for such an important contribution. ⌖

James C. Peterson, *editor-in-chief*

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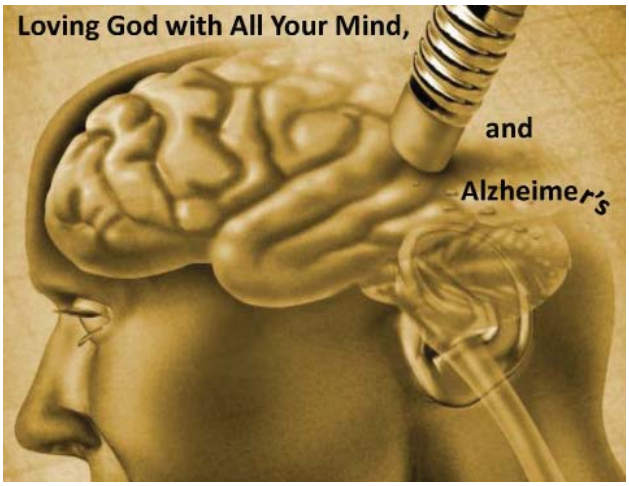
Bryan C. Auday, PhD, is Professor and Chair of the Department of Psychology at Gordon College, Wenham, MA, and is also the founding director of the neuroscience program there. He recently completed, as co-medical editor, the *Salem Health Magill's Medical Guide*, 7th ed., vols. 1–5 (Hackensack, NJ: Grey House, 2014).



In his essay "Loving God with All Your Mind and Alzheimer's," at http://www.csca.ca/wp-content/uploads/2017/01/Auday2016.pdf, Auday describes for us the latest developments and challenges from Alzheimer's disease for the sciences, our society, and Christian faith. The essay is intended as an invitation. Readers are encouraged to take up one of the insights or questions, or maybe a related one that was not mentioned, and draft an article (typically about 5,000–8,000 words) that contributes to the conversation. These can be sent to Auday at Bryan.Auday@gordon.edu.

Auday will send the best essays on to peer review and then we will select from those for publication in an Alzheimer's science theme issue of *Perspectives on Science and Christian Faith*.

The lead editorial in the December 2013 issue of *PSCF* outlines what the journal looks for in article contributions. For best consideration for inclusion in the theme issue, manuscripts should be received electronically before **May 1, 2017**.

Looking forward to hearing your perspectives,

James C. Peterson, *Editor-in-chief*

Justin L. Barrett

Cognitive Science of Religion and Christian Faith: How May They Be Brought Together?

Justin L. Barrett

The past twenty years has seen the emergence of an interdisciplinary study of religious thought and action known as cognitive science of religion (CSR). In this article, CSR is introduced and potential connections with Christianity are highlighted. In addition to presenting CSR's relationship with cognitive science more generally along with its brief history, common misunderstandings about CSR are addressed. The article concludes with a brief discussion of several areas that may be of particular concern to Christian audiences, including whether CSR may "explain away" religious beliefs, whether it may help provide insights concerning God's general revelation to humans, what role it could play in helping craft a theological anthropology, and what practical implications it may have for religious education and other activities of churches.

I once participated in an academic conference on a small island in the Baltic Sea that was uninhabited except for a biological research station. It was summer and the weather was fair, so during a break I took a walk in the woods with another conference participant. He was an atheist. In an isolated part of the woods with no other humans within sight or earshot, we came upon a beautiful wooden chapel from the days when this island had been a leper colony. Perhaps two hundred years old, the chapel looked like something out of a fairytale; we just had to peek inside.

No one was in it, but it had marvelously carved pews, chancel, and pulpit. I was effervescing about how beautiful it was and noticed that my conversation partner's voice had fallen to hushed tones once we entered the chapel. His quiet speech was particularly notable because there was obviously no one to disturb in this space. Wanting to take a better look at the pulpit, I went to climb the stairs and my companion grabbed my arm stopping me. He was evidently alarmed. Why? I was about to violate sacred space. I explained that, at least in my Christian tradition, I was perfectly entitled to examine the pulpit, but he—an atheist—was not convinced: I ought not to climb the stairs to the pulpit. To protect his sensitivities, I did not.

I share this story not to parade my own irreverence but to illustrate how even people with no religious background or commitments can have intuitions about religious places and their actions therein. Where did my friend's intuitions come from and why were they so strong that, even with no one to witness the alleged offence, he could not raise his voice or tolerate my alleged violation of the sanctity of this place? What accounts for the apparent contradiction between my friend's explicit beliefs concerning gods or sacredness, and his behaviors? A new scientific approach to the study of religion called the *cognitive science of*

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religion purports to answer these sorts of questions. Many who work in this area believe that by virtue of being human beings and growing up in ordinary human environments, we acquire certain tendencies in thought and action that easily accommodate—or even embrace—religious thought. Indeed, religious thought and action is so ubiquitous in human societies because our minds are naturally ready for it. In this article, I briefly introduce the cognitive science of religion and share a few reasons why Christians should both be interested in and involved with it.

What Is Cognitive Science?

Before turning to the cognitive science of religion, I must first introduce cognitive science. Cognitive science (or the cognitive sciences) is an interdisciplinary area of study that is focused on minds. How do minds work? What does it mean to think, perceive, and know? How are human minds similar and different from animal minds or computer minds? Cognitive science, then, overlaps substantially with psychology, but also includes contributions from anthropology, computer science (especially artificial intelligence), linguistics, neuroscience, and philosophy. Specific areas of focus within cognitive science include how we see, hear, and otherwise perceive the world around us, how we learn new things, how various memory systems work, language, problem solving, creativity, and many others.

It is easy to confuse cognitive science with neuroscience. While the two often interact and at some points overlap, they are different. As cognitive science deals with minds and thought systems, neuroscience deals with brains and nervous systems. To some ears, that might seem like a distinction without a difference. Aren't nervous systems responsible for thinking? The distinction between minds and brains also helps distinguish between different types of research questions and answers. Consider two analogies. First, cognitive science is to neuroscience as nutrition is to gastroenterology. Suppose you want to know what you should be eating for a healthy and energetic lifestyle. The relevant information you need concerns selecting particular foods because of the nutrients they have and the nutritional needs of your body. A nutritionist is the expert you need to consult. You are not concerned with how your stomach and intestines work to extract the nutrition from your food even if that may undergird your nutritionist's recommendations. Likewise, consider the difference between software and hardware on your computer. When you have some work to do on your computer—like creating a spreadsheet to manage home finances or designing a birthday invitation—you need expertise concerning the software. If you want to know how the operating system works, or how to use a specific program, and you called a computer helpline and were given explanations about microchips and motherboards, you would rightly be displeased. The hardware of a computer is only indirectly relevant to creating a birthday invitation on your computer. In some respects, minds are to brains as software is to hardware.

In the sixty years that cognitive science has been around, one of its greatest discoveries is that human minds process information differently depending upon what the information is used for or what it is about. For instance, we process the sight of other people's faces differently than we do the sight of flowers or cows. Natural human languages are processed very differently than artificial languages such as binary code. We think differently about objects that are "things" that we might be about to interact with physically than we do about other objects. All of this is to say that human minds are not passive absorbers of information; rather, they actively shape and transform information as it comes in.

If this sounds very abstract and impractical, consider the fear of snakes. Humans (and other primates) tend to react dramatically to the presence of snakes. We do not just ignore them as we might a nearby crow, turtle, or squirrel. Snakes or even snake-like forms and movement command our attention. Most of us are at least a bit uncomfortable around snakes, if not absolutely terrified. Why do we so easily learn to become afraid of snakes? It turns out that human minds are naturally prepared to form fear associations with snakes and snake-like things. A garter snake and a rose may be comparably dangerous to humans, but a child only needs to see a parent respond in fear once to a garter snake and they will likely form a fear of it, whereas dozens of parental fear reactions to a rose will probably result only in the child thinking there is something wrong with the parent!

Cognitive science has shown that human minds have natural processing predilections and biases—that they are not well characterized as a single, all-purpose generic information processor like personal computers from the 1980s. Cognitive scientists

continue to scrap over the degree of the mind's specialized subsystems or biases, where they come from, and how rigid they are; but the fact that the typical human has a specialized and contoured mind is certain. Human minds are not just extra powerful sparrow minds or a variation on the mind of a humpback whale. Human minds help us think and learn in specifically human ways.

With this fact in hand, a very interesting possibility presents itself: could it be that human tendencies to believe in superhuman beings such as ghosts, spirits, and gods could be in part a result of the type of minds that humans have? Might the well-documented human proclivity toward ritual be a product of the natural features of human minds?

What Is Cognitive Science of Religion (CSR)?

CSR takes insights from cognitive science and applies them to perennial questions in the study of religion. For example, what accounts for the distribution of contemporary forms of religious expression? how do we explain historical patterns of change and resiliency in religions? and what are the consequences of different types of religious expression on humans as individuals and as societies? Perhaps partial answers to these sorts of questions can be found in the ordinary functioning of human minds.

Where did CSR come from?

Though the roots of cognitive approaches to the study of religion reach back to the 1970s,[1] the moniker "cognitive science of religion" first appeared in 2000 to describe the body of work in the 1990s and later; these studies looked at how cross-culturally recurrent features of human minds seemed to inform and constrain certain types of cultural expression that we might recognize as religious.[2] The fundamental insight of CSR maintained that since human minds find it easier to think in some ways as opposed to others, then ideas, actions, and other types of expression that match up well with what human minds naturally do well are more likely to persist and spread to the point of being recognizably "cultural." That is, cultural expression is not random or arbitrary but is at least partially explainable in terms of how human minds tend to work. If that is so, then the same could be argued for religious cultural expression. Explaining religious expression from this perspective becomes an exercise in trying to explain why it is that certain modes of thinking and acting that we might call "religious" are supported by the way that human minds work.

This novel approach to the study of religion has become attractive to a number of religious studies scholars because of two virtues. First, appealing to features of human minds enables the making of *testable* predictions and explanations concerning religious expression within and across cultures. One challenge to any study of culture is to get beyond arguing that some people groups think or act the way they do essentially because their peers and ancestors did likewise. Consider why it is that children on playgrounds believe that boys or girls have cooties. We can say that they believe in cooties because other children taught them about cooties, but why did those children believe in cooties? Because some other children believed in cooties? But why did *they* believe in cooties? Eventually we need to find an originator of the whole cooties question and also account for why this idea persisted, whereas other playground games and concepts disappeared. When cultural expression is explained only in terms of previous cultural expression, we quickly run into explanatory brick walls or indefinite regresses. Appealing to a noncultural factor, such as how human minds work, provides an additional and powerful explanatory tool.

The second reason that CSR has become attractive to many scholars is that it leaves aside the truth of religious commitments. Rather than a glib, "people believe in ghosts because they are real," CSR tries to explain why people have the beliefs they do aside from whether the beliefs are true or false—sometimes called methodological agnosticism. After all, just because something is true does not mean people will believe it, and, conversely, many false ideas are widely believed. Remaining neutral with regard to the religious claims democratizes this approach to the study of religion. Believers and nonbelievers can (and do) collaborate in CSR scholarship.

What is it finding?

Probably the most important reason for the rise of CSR is neither its methodological agnosticism nor its ability to give explanations from outside cultural particulars. The most important reason is that it has

proven to be capable of making novel testable predictions and explanations.

To begin, CSR has been helpful when accounting for local and cultural particulars that are otherwise difficult to explain. To illustrate, Emma Cohen conducted ethnographic field research in the northern Brazilian city of Belém as part of her doctoral training.[3] There she investigated the religious practices of Afro-Brazilian spiritualists who gathered together for healings and insights gleaned from episodes of spirit possession. Through her extensive observations and interviews over many months, she discovered something peculiar: the way spirit possession was described and taught by the leader of the cult-house (the *pai-de-santo*) was not the same as it was understood by the laity. Even though the laity affirmed the authority and the trustworthiness of their spiritual guide, and even though they were taught spirit possession from him, they did not understand spirit possession in the same way. What was taught was not the same as what was received—but why? Cohen's ethnography and subsequent experiments, combined with appeals to other research, suggest that the explanation for spirit possession offered by the *pai-de-santo* is too conceptually difficult—an ill fit with how humans naturally think about the relationship between minds and bodies—for it to be easily remembered, talked about, or used to reason about their experiences.

Findings from CSR have been used to make sense of local peculiarities in religious expression from contemporary Melanesia to the Reformation in Europe,[4] but it is probably best known for its efforts to explain broad, cross-cultural questions concerning why people generally tend to be religious throughout history and around the globe, and why some religious ideas are common while others are not.[5] Some have regarded CSR as having promise for naturalistically "explaining religion,"[6] an issue I take up below.

The sort of explanations CSR offers are diverse, but they generally take the form of specifying some aspect of what might be considered "religion" (e.g., belief in superhuman invisible beings, use of rituals to solve problems, belief in an afterlife), and then identifying what ordinary psychological dynamics would make humans particularly attracted to the thought behind these aspects of "religion." If there is a conceptual system that is part of ordinary human psychology, then ideas that resonate with that conceptual system's typical way of thinking are more likely to be entertained by individuals and eventually spread across groups than ideas that do not resonate with these conceptual systems. As an example, let us examine the belief in superhuman invisible beings (i.e., gods).

From a CSR perspective, the pervasive belief in gods that are responsible for acting on the natural world is partially explained by the apparent fact that humans have minds naturally prone to explaining features of the world in terms of the actions of minded, intentional beings.[7] In a large body of research, Deborah Kelemen and her collaborators have shown that children in the UK, the US, Romania, and China are naturally disposed to say that animals and other natural objects are the way they are for a particular purpose or function.[8] For instance, birds are here to look pretty and rivers are here so that we have a place to go fishing. This purpose-based reasoning is readily attached to intentional reasoning: someone must have intended the purpose. Of course, the step from thinking that animals are here for a purpose and that someone must have intended the purpose makes it very easy for children to believe that an animal is here because a god designed it for people in a certain way. More recently, Kelemen has provided evidence (from the US, Romania, and China) that these purpose-based reasoning biases persist into adulthood unless they are tamped down by formal education or another rigorous form of enculturation.[9] Taken together, Kelemen's work suggests that human attraction to the idea that superhuman beings may account for the way things are in the world is a result of ordinary cognitive tendencies. Why humans have such tendencies is another question that remains without consensus answers.

Though the typical emphasis in CSR is on beliefs and ideas, scholars using cognitive approaches have also attempted to account for why religious rituals have frequently recurring features across cultural settings. For instance, Pierre Liénard and Pascal Boyer have argued that a natural human cognitive-emotional system for dealing with unseen contaminants or pathogens helps drive the performance of cleansing rituals and accounts (in part) for why they are so common across cultures.[10] E. Thomas Lawson and Robert McCauley have developed a theory that allegedly explains why religious rituals tend to cluster

around two types: (1) those that are performed infrequently in the life of a participant, are high in sensory adornment ("bells and smells") and emotional tenor, and are potentially ritually reversible; and (2) those that are performed repeatedly, are relatively low in hoopla and emotionality, and that people would not dream of attempting to ritually undo.[11]

This general theme—that some combination of cross-culturally recurrent conceptual systems in human minds makes belief in gods and an afterlife and engagement in rituals relatively intuitive and attractive to people—is common in CSR even if the specific account varies. Examples of treatments include Stewart Guthrie's *Faces in the Clouds,*[12] Scott Atran's *In Gods We Trust,*[13] Robert McCauley's *Why Religion Is Natural and Science Is Not,*[14] Jesse Bering's *The Belief Instinct,*[15] and my own *Born Believers*.[16] Representatively, in his book *Religion Explained*, Pascal Boyer writes that because of how human minds naturally work, "It does not require much effort to have religious beliefs" (p. 299).[17]

Clearing Up Some Common Misconceptions about CSR

Whether critiquing the field or participating in it (or both), it is important to recognize that, like most scientific approaches to a particular subject matter, CSR is constantly changing. At its core, it is about leveraging findings and theories from the cognitive sciences to help account for religious expression. Consequently, as the cognitive sciences change, so will CSR. Indeed, a scholar's own particular views about cognitive science will affect his or her cognitive science of religion. Beyond the view that humans share certain core cognitive/psychological dynamics (barring pathology or developmental abnormality) and that this cognition informs and constrains the like range of religious expression, CSR has no non-negotiable commitments.

Nevertheless, because some popularizers of CSR bring to their writing their own idiosyncratic sets of assumptions and perspectives, observers of the field may think that these assumptions are foundational to CSR. This dynamic has led to an assortment of common misconceptions about CSR that I have encountered when I speak about the area or discuss it with colleagues. I shall try to remedy a few of these below.

No particular model of human minds

No solitary understanding of how human cognitive systems work holds complete sway in the cognitive sciences. For instance, some cognitive scientists regard the "mind as computer" metaphor as helpful, others reject this metaphor, and still others say that it is not a metaphor but that human minds do computations and, thus, *are* computers.[18] Some cognitive scientists regard all thought as being fundamentally composed of sensory and behavioral experiences whereas others see minds as forming more-abstract representations that cannot be reduced to these experiences. These debates are the sort of high-level questions that get cognitive scientists out of bed in the morning, but those who study religion cannot wait until cognitive scientists all agree in order to get on with their work. Each scholar adopts the model they think best captures the available data and is most useful for their explanatory task. In this way, it would be wrong to say CSR is committed to a particular model of the mind.

CSR does not assume modularity

One contentious model of the human mind is whether or not the human mind has *modules*. That is, roughly, whether the mind is organized into largely independent subsystems that, once triggered, operate in isolation from each other. Cognitive scientists disagree about what *modularity* means, whether humans have modules, how many modules they might have, and what the relationship is between modules and specific underlying brain architecture (e.g., do "modules" require dedicated neural networks and must these neurons be in just one neighborhood in the brain?).[19] Cognitive scientists of religion likewise disagree on these matters. However, they commonly construe the mind as using specific and different methods for handling at least some classes of information that are particularly important to humans. So, for instance, human faces are processed in ways that are relatively distinctive in comparison to other kinds of visual information; basic physical objects appear to trigger a host of expectations concerning their basic attributes beginning in infancy. This kind of specialized processing is frequently termed *domain-specific* cognition and is often conflated with modularity even though it does not require modularity in the usual sense of that term.

CSR does not assume materialism

Christians and other religious observers may infer that CSR assumes humans are only physical, material beings and that human minds are ultimately reducible to the neuro-electro-chemical activities that characterize a functioning human brain. It is easy to see why it looks like CSR is committed to such a view. CSR does not (typically) bring the possibility of nonmaterial entities and factors into its causal accounts. The reason is simple: essentially all the scholarly community agrees that the physical and material properties of being human (e.g., having a body with particular biological properties, living in a material world, etc.) impinge upon how humans think and act. Even if one believes in an immaterial soul that is somehow instantiated in a body, the body (and brain) matters a lot. Since this premise is common ground, explanation building will tend to see how far it can go, just by resting on this shared foundation. It does not follow, however, that all CSR scholars reject the existence of nonmaterial realities such as gods or even nonmaterial human minds or souls.[20] The science simply does not make use of such possibilities.

CSR need not be evolutionary (in the usual sense)

Though CSR has been drawing ideas from evolutionary psychology for about fifteen years, and in the past ten has begun finding points of contact with evolutionary studies of religion, cognitive approaches need not be evolutionary—at least in the typical sense. As cognitive science has increasingly sought to use evolutionary theories to explain why human minds are the way they are, CSR has likewise made reference to these evolutionary theories. Nevertheless, it is possible to take the findings of cognitive science as unexplained brute fact and apply these facts to the study of religion in much the same way that early theorists such as Lawson and Harvey Whitehouse did.[21] They began with observations about how the human mind operates and remained largely silent about *why* human minds would operate that way. For instance, Whitehouse was concerned with how Melanesians remembered complex and dramatic rituals over long periods of time without written records, and found resources in the study of flashbulb memories (vivid memories of events of great personal significance even over decades) to account for these ritual performances. Whitehouse did not have to appeal to evolution to account for why flashbulb memories are formed the way they are; he simply applied cognitive psychology to a particular anthropological question.

It is the case, however, that much of CSR uses a different sort of evolutionary approach: cultural evolution. Scholars in this area typically reason that if a religious idea or practice is going to persist and spread successfully enough that we would recognize it as "religious" and not just an oddity of a few individuals, then those religious ideas need to survive a kind of selection process. Lots of ideas bubble into human minds for lots of reasons, but we need to account for why some survive and others do not.[22] In this sense, evolutionary thinking is used, but only as it concerns the evolution of cultural expression, and not in connection with the features of human biology.

CSR does not assume that cultural particulars do not matter

Because the most well-known CSR publications are books that paint broad pictures about whether religion is natural in some sense or why people believe in gods and the like, it may appear at first glance that CSR says nothing about cultural particulars or that cultural factors do not matter in religious expression. Such a characterization is demonstrably false, as already suggested above. CSR projects have long included those that try to marry cognitive predilections with local particulars.[23] What sets CSR off from many other approaches to the study of religion and culture is its insistence that not all human expression is merely or entirely the result of the particular history or culture of specific people. To see what is locally distinctive we need to know better what is cross-culturally common. CSR is also characterized by a tendency to see how far pan-cultural psychological dynamics can go toward explaining a particular form of religious expression before appealing to local specifics.

Why Might Christians Care?

In my experience of presenting this research area, even a brief overview such as the one above provokes anxiety in some Christians and excitement in others. The anxiety comes from the concern that CSR is yet another in a long line of attempts to "explain away" or undercut the justification for belief in God

or other Christian doctrinal foundations. The excitement, however, comes from seeing the possibility of scientific findings that resonate with theological notions or that may be useful for ministry. I sketch some of these possibilities below. As will be evident, this is meant as a few illustrative pointers only, toward some questions and applications that need to be explored by Christian scholars and ministry leaders.

Explaining away?

A cursory reading of many books and articles in the cognitive science of religion area may give the impression that CSR entails an "explaining away" of religious thought. Boyer referred to religious ideas as "airy nothing,"[24] and Ara Norenzayan in *Big Gods* likens religion to a ladder that humanity can now kick away.[25] Jesse Bering refers to God as "a sort of evolved blemish etched onto the core substrate of your brain."[26] Though it is certainly true that many scholars working in the CSR area are not theists or otherwise religious, and their disbelief can be glimpsed through their writings, it does not follow that CSR entails atheism or rejection of religious beliefs and practices.

What is fairly obvious is that having a scientific, psychological explanation for why people are inclined to believe in a god, for instance, does not by itself imply that one should not believe in a god. Undoubtedly, there is a scientific explanation to be discovered—likely an imperfect one—for why it is that certain people are inclined to believe that souls are distinct from bodies, for instance. There is also likely to be a scientific explanation for why it is that some people are inclined to believe that souls are not distinct from bodies. Whether one has (or does not have) a scientific explanation for holding a belief is independent of whether the belief is true or false. The same applies to explaining why some people believe God exists and some people believe God does not exist. To make the inference that a belief is false because it has a scientific cause—even a psychological or evolutionary cause—is to commit what philosophers call a *genetic fallacy:* even a dubious cause or origin of a belief does not necessarily mean that the belief in question is false.

To make the leap from there being a cognitive cause (or causes) that contributes to religious beliefs to the conclusion that these religious beliefs are somehow unjustified takes considerably more work than simply observing that such causes are now coming into focus. Whether or not findings and theories from CSR—particularly those concerning god-beliefs—support, challenge, or are neutral with regard to the truth, rationality, or justification of religious claims is an ongoing discussion among philosophers.[27]

Future research could examine more specifically how such scientific findings bear upon specific religions and religious beliefs. That is, instead of trying to argue broadly whether CSR "explains away" religion, it may be more helpful to consider whether CSR theories or findings undercut or support specific beliefs such as the existence of the Abrahamic God, Chinese ancestor-spirits, or Hindu reincarnation. It would be surprising if CSR has the same implications for all religious beliefs regardless of tradition or the specific belief.

Theological insights

It may turn out that CSR will provide evidence that can influence how we should think about many Christian theological ideas. I offer just two related examples: revelation and human nature.

In many Christian traditions, God is regarded as revealing himself through general revelation and through special revelation—particularly through scripture. This general revelation, which is accessible to anyone, gets expressed in various ways. Perhaps God reveals something about the divine character and attributes through creation, accessible directly through the senses. Maybe reason and reflection are resources given to us to better understand God. Additionally, common human experiences and cultural expression, including mythologies and moral codes, may be part of this general revelation, providing glimpses of the God who created us all. CSR holds the potential to influence this discussion. What are the ways in which people untutored by the special revelation of the Bible tend to naturally catch glimpses of God in the natural world? Are there patterns of thought that humans naturally gravitate toward when it comes to reflecting on human purpose and values that might be gifts pointing us toward the Gospel? Which patterns in mythology and moral codes from around the world are genuine and which of them reflect something about how God might be revealing himself to all peoples? CSR

has tools and insights that might be turned to these questions.

In a related way, CSR may give us insights regarding human nature. For instance, a God-shaped void in our hearts or an inchoate sense of the divine or *sensus divinitatis* has been posited by theologians throughout the centuries as part of human nature. We have theological grounds for suspecting such a feature of humanity, but do we have scientific evidence? If yes, what does that evidence tell us about the properties of this *sensus divinitatis,* such as when it is triggered and what it delivers to us in terms of beliefs or behaviors? Whose model of the *sensus divinitatis* is most likely to be accurate? Kelly James Clark and I have previously suggested that CSR may provide evidence relevant to these questions,[28] but a full treatment that will motivate new scientific and theological scholarship is yet to be done. Another question concerning human nature is the perennial theological question: What does it mean to be created in God's image? Assuming that being capable of a loving, personal relationship with God or being able to represent God in the creation is a key component of what it means to be God's image bearers, then CSR may contribute to discovering just what sort of conceptual equipment is related to these capacities and how they develop in humans.[29]

Practical implications

An intellectual feast may await Christian scholars concerned with these lofty theological questions, but CSR can also be usefully harnessed in practical ways in the church. Three areas come to mind for me: religious education for children, identifying challenging teachings for adolescents and adults, and rethinking rituals.

Often when we consider how to educate children, we assume uncritically that children's minds are amazingly pliable and that they will acquire almost any ideas, given the right motivation and instruction. Cognitive science teaches us that the story is not so simple. Children learn some things at specific points in their development more rapidly than at other times, and all of us are more naturally receptive to certain types of information over other types. That is, children are not blank slates waiting to be written upon or sponges that passively absorb their environment; they are active participants in shaping what it is that they will learn. Their learning is not determined by their will or their interest alone. The dynamics of their minds also influence what they will learn. CSR has begun applying these insights to how children's minds handle religious ideas. So, for instance, CSR has produced evidence that thinking about God as immortal, superpowerful, and superknowing is not as challenging to even five-year-olds as has often been assumed.[30] How to adequately harness these natural dispositions toward learning is yet to be adequately explored, but the potential exists to greatly improve upon common current practices.

CSR has also provided tools for identifying which theological teachings are likely to be especially challenging to adolescents and adults and why. As human minds develop, they acquire characteristic intuitions and heuristics that structure the dynamics of thought, but these tendencies then also make ideas that run counter to these intuitions, that is, *counterintuitive* ideas, more challenging. For instance, it may be that humans naturally form in-groups and outgroups, and it is easiest for the in-group to be people who are like us in terms of manner of speech, eating practices, and other customs. Successfully internalizing the idea of loving those who do not easily and naturally appear to be "neighbors" may require extra attention, particularly by identifying the cues we naturally use to identify in-group members and learning to see these cues better in others. Likewise, the concept of undeserved forgiveness and blessings in the face of guilt, known as *grace*, may run against our natural sense of tit-for-tat fairness. The doctrine of grace, then, may require extra attention in teaching and discipleship in order to override natural obstacles.

One of the older areas of attention in CSR is religious rituals and other practices. Interestingly, from a disinterested "outsider" perspective, scholars such as E. Thomas Lawson, Robert McCauley, Richard Sosis, and Harvey Whitehouse have built a case for the importance of collective religious actions in drawing communities together, marking important life transitions so that members of a community recognize those transitions as divinely sanctioned, and otherwise motivating religious communities to keep interacting with their God or gods.[31] McCauley and Lawson, for instance, observe that highly motivating rituals with enormous amounts of emotionally evocative pageantry that help people *feel* that God is acting in, say, uniting two people, transforming a child into an adult, or making an ordinary building

into a sacred space, are largely absent in contemporary North American Protestantism.[32] This fact, they suggest, may be detrimental to the commitment of churchgoers to their faith.

Conclusion and Invitation

As is probably obvious, this article was not meant as an exhaustive introduction to the cognitive science of religion with well-delineated implications for Christian scholars or ministry leaders. Rather, my aim here was to present enough background on CSR to pique interest in this area. Though interest in the area on the part of Christians is growing, Christian voices remain disproportionately few in scholarship in and around CSR; progress in applying this new scientific study of religion to distinctively Christian concerns and problems remains in its infancy. My hope is that this essay will encourage other Christians to explore CSR critically but constructively in order to discover how this scholarly area may service Christ and his church. ✠

Notes

[1]Dan Sperber, *Rethinking Symbolism* (Cambridge, UK: Cambridge University Press, 1975).

[2]Justin L. Barrett, "Exploring the Natural Foundations of Religion," *Trends in Cognitive Sciences* 4, no. 1 (2000): 29–34.

[3]Emma Cohen, *The Mind Possessed: The Cognition of Spirit Possession in an Afro-Brazilian Religious Tradition* (New York: Oxford University Press, 2007).

[4]Harvey Whitehouse, *Inside the Cult: Religious Innovation and Transmission in Papua New Guinea* (Oxford: Oxford University Press, 1995); Theodore M. Vial, *Liturgy Wars: Ritual Theory and Protestant Reform in Nineteenth-Century Zurich* (New York: Routledge, 2004).

[5]Scott Atran, *In Gods We Trust: The Evolutionary Landscape of Religion* (New York: Oxford University Press, 2002), 57; Justin L. Barrett, *Why Would Anyone Believe in God?* (Walnut Creek, CA: AltaMira Press, 2004).

[6]Pascal Boyer, *Religion Explained: The Evolutionary Origins of Religious Thought* (New York: Basic Books, 2001).

[7]Stewart E. Guthrie, *Faces in the Clouds: A New Theory of Religion* (New York: Oxford University Press, 1993); Jesse M. Bering, *The Belief Instinct: The Psychology of Souls, Destiny, and the Meaning of Life* (New York: W. W. Norton, 2011).

[8]Deborah Kelemen, "Why Are Rocks Pointy? Children's Preference for Teleological Explanations of the Natural World," *Developmental Psychology* 35, no. 6 (1999): 1440–52; Deborah Kelemen and Cara DiYanni, "Intuitions about Origins: Purpose and Intelligent Design in Children's Reasoning about Nature," *Journal of Cognition and Development* 6, no. 1 (2005): 3–31.

[9]Krista Casler and Deborah Kelemen, "Developmental Continuity in the Teleo-Functional Explanation: Reasoning about Nature among Romanian Roma Adults (Gypsies)," *Journal of Cognition and Development* 9, no. 3 (2008): 340–62; Deborah Kelemen and Evelyn Rosset, "The Human Function Compunction: Teleological Explanation in Adults," *Cognition* 111, no. 1 (2009): 138–43; Elisa Järnefelt, Caitlin Ford Canfield, and Deborah Kelemen, "The Divided Mind of a Disbeliever: Intuitive Beliefs about Nature As Purposefully Created among Different Groups of Nonreligious Adults," *Cognition* 140 (2015): 72–88.

[10]Pascal Boyer and Pierre Liénard, "Why Ritualized Behavior? Precaution Systems and Action Parsing in Developmental, Pathological, and Cultural Rituals," *Behavioral & Brain Sciences* 29, no. 6 (2006): 595–613; Pierre Liénard and Pascal Boyer, "Whence Collective Ritual? A Cultural Selection Model of Ritualized Behavior," *American Anthropologist* 108, no. 4 (2006): 814–27.

[11]E. Thomas Lawson and Robert N. McCauley, *Rethinking Religion: Connecting Cognition and Culture* (Cambridge, UK: Cambridge University Press, 1990); Robert N. McCauley and E. Thomas Lawson, *Bringing Ritual to Mind: Psychological Foundations of Cultural Forms* (Cambridge, UK: Cambridge University Press, 2002).

[12]Guthrie, *Faces in the Clouds*.

[13]Atran, *In Gods We Trust*.

[14]Robert N. McCauley, *Why Religion Is Natural and Science Is Not* (New York: Oxford University Press, 2011).

[15]Bering, *The Belief Instinct*.

[16]Justin L. Barrett, *Born Believers: The Science of Children's Religious Beliefs* (New York: Free Press, 2012).

[17]Boyer, *Religion Explained*.

[18]Though a bit dated now, a great introduction to these and other central issues in cognitive science is Paul Thagard, *Mind: Introduction to Cognitive Science* (Cambridge, MA: MIT Press, 2005).

[19]Peter Carruthers and Andrew Chamberlain, eds., *Evolution and the Human Mind: Modularity, Language and Meta-cognition* (Cambridge, UK: Cambridge University Press, 2000); Jerry A. Fodor, *The Modularity of Mind* (Cambridge, MA: Bradford Books, 1983).

[20]Justin L. Barrett, *Cognitive Science, Religion, and Theology: From Human Minds to Divine Minds* (West Conshohocken, PA: Templeton Press, 2011).

[21]Lawson and McCauley, *Rethinking Religion*; Whitehouse, *Inside the Cult*.

[22]Dan Sperber, *Explaining Culture: A Naturalistic Approach* (Oxford: Blackwell Publishers, 1996).

[23]For instance, see Cohen, *The Mind Possessed*; Brian Malley, *How the Bible Works: An Anthropological Study of Evangelical Biblicism* (Walnut Creek, CA: AltaMira Press, 2004); McCauley and Lawson, *Bringing Ritual to Mind*; Whitehouse, *Inside the Cult*; and Harvey Whitehouse and Luther H. Martin, *Theorizing Religions Past: Archaeology, History, and Cognition* (Walnut Creek, CA: AltaMira Press, 2004).

[24]Boyer, *Religion Explained*, for instance, on page 4.

[25]Ara Norenzayan, *Big Gods: How Religion Transformed Cooperation and Conflict* (Princeton, NJ: Princeton University Press, 2013), 172.

[26]Bering, *The Belief Instinct*, 37.

[27]For a collection of essays that address these issues, see Roger Trigg and Justin L. Barrett, eds., *The Roots of Religion* (Farnham, Surrey: Ashgate, 2014).

[28]Kelly James Clark and Justin L. Barrett, "Reformed Epistemology and the Cognitive Science of Religion," *Faith and Philosophy* 27, no. 2 (2010): 174–89.

[29]Justin L. Barrett, "Metarepresentation, *Homo religiosus,* and *Homo symbolicus,"* in *Homo Symbolicus*, ed. C. Henshilwood and F. d'Errico (Amsterdam: John Benjamins, 2011),

205–24; Justin L. Barrett and Matthew J. Jarvinen, "Evolutionary Byproducts and *Imago Dei*," in *The Emergence of Personhood: A Quantum Leap?*, ed. M. Jeeves (Grand Rapids, MI: Eerdmans, 2015), 163–83.

[30]Barrett, *Born Believers*.

[31]McCauley and Lawson, *Bringing Ritual to Mind*; Richard Sosis and Bradley J. Ruffle, "Religious Ritual and Cooperation: Testing for a Relationship on Israeli Religious and Secular Kibbutzim," *Current Anthropology* 44, no. 3 (2003): 713–22; Harvey Whitehouse, *Modes of Religiosity: A Cognitive Theory of Religious Transmission* (Walnut Creek, CA: AltaMira Press, 2004).

[32]McCauley and Lawson, *Bringing Ritual to Mind*.

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Robert E. Sears

The Nature of Experience: Empirical Considerations and Theological Ramifications

Robert E. Sears

Recent theological writings indicate that theological conclusions are, to some extent, predicated on theologians' understandings of experience. Furthermore, recent and contemporary theologians are not unified in their understandings. George Lindbeck recognizes this scenario in his influential work The Nature of Doctrine *(2009/1984), in which he also describes two opposing ideologies as experiential-expressivism and cultural-linguistic theory. The former is ignorant of social construction and therefore claims that religious experiences are identical across cultures; the latter recognizes social construction and therefore claims that religious experiences are different across cultures. While many theologians tend toward one of these views, neither is sufficient from a perspective informed by cognitive science. In conjunction with studies of cognition, affect, and behavior, this article argues for a revised understanding of experience that recognizes the principles of mediation and degrees of cross-cultural sharing. Some implications of this revised understanding for interreligious dialogue and theology of religions will then be discussed.*

A wide-ranging survey of major theological thinkers and their works from the past half century indicates that human experience figures into theological method and reflection. Catholic theologian David Tracy speaks of theological method as marrying insights from "common human experience" with the "Christian fact" (primarily scripture).[1] Karl Rahner, perhaps the most prominent Catholic theologian of the twentieth century, was heavily reliant on existential analysis of the human condition for framing his theological reflections.[2] George Lindbeck, a Lutheran contemporary of Rahner, has argued that one's theological methodology must be able to "handle the anthropological, historical, and other nontheological [i.e., empirical or scientific] data better than do the alternatives" in order for it to be viable.[3] More recently, Gerald McDermott and Harold Netland, both evangelical Protestants, have argued that theology of religions should take into account phenomenological analyses of the religions themselves.[4]

While there is broad agreement among recent/contemporary theologians that experience is an important source for doing theology, there is significant disagreement over the way experience is handled and generally understood. These disagreements have led to some animated debates between proponents of various methodologies who, needless to say, often vary from one another in terms of their theological and practical conclusions. One of the most visible debates over the past forty years is between so-called liberals (experiential-expressivists) and postliberals (cultural-linguistic sympathizers). Lindbeck, one of the most

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influential advocates of the postliberal tradition, has characterized the debate as follows:

> The cultural-linguistic understanding of the relation between religion and experience is in direct opposition to that of experiential-expressivism. If one pictures experience as inner and religion as outer, then the outer rather than the inner is prior in the cultural-linguistic approach. Different religions are not outward manifestations of the same basic experience that underlies all of them, but, like cultures and languages, they shape the raw material of human potentialities into different, sometimes mutually exclusive, experiences of self, community, and world. What comes first is not a universal sense of ultimacy that is then diversely conceptualized and symbolized in particular religions, but rather particularity comes first and particularizes whatever it is that different religions take to be ultimate.[5]

While Lindbeck may be guilty of essentializing the views of complex thinkers to derive his twin categories,[6] there can be little doubt that his distinction possesses some legitimacy—not to mention heuristic value. Moreover, other scholars have advocated elements of Lindbeck's position (as opposed to rival conceptualizations) or described a similar bifurcation in theological methodology.[7]

This article begins with the contention that the postliberal position of Lindbeck and others captures something of importance that many scholars aligned with the liberal or experiential-expressivist position fail to appreciate sufficiently. At the same time, Lindbeck's construal of the postliberal position contains its own problems, which result in the erroneous impression that commonality between different religious systems—and the experiences they afford—is coincidental, trivial, or lacking. Common human experience—a given for liberal theologians but generally a source of scorn for Lindbeck and other postliberals—is something that must be reclaimed and rearticulated while acknowledging postliberal concerns.

To be sure, similar sentiments can be found in the works of theologians other than Lindbeck who likewise claim to reject theological liberalism. David Tracy (who Lindbeck actually considers to be a liberal theologian) accepts common human experience in tension with the fact that human selves are profoundly influenced by particular relationships and circumstances.[8] William Placher, an avowed postliberal who feels indebted to Lindbeck, wants to carve out space for a position between natural theology and fideism—which are associated with universal and relativistic experiencing, respectively.[9] Similarly, McDermott and Netland seek to defend "the particularity of Christian revelation and the uniqueness of Christian spirituality" while upholding natural theology.[10] Although each of these proposals may belong to the same genus (with regard to intent), the rationales and particular conclusions differ from one another. So it is that my proposal shares similar concerns with these authors but proceeds with a distinctive line of argument.[11]

In brief, I will make the case for a revised experientialist perspective (as opposed to the experiential-expressivist or cultural-linguistic paradigms), which draws its theoretical underpinnings from cognitive science and is supported by empirical analysis. This perspective claims that while culturally/religiously distinct people do not have identical experiences, they can have very similar experiences on account of shared humanity and environmental conditions, which ground cultural and religious systems.

The following section builds a case for the revised experientialist position contra experiential-expressivist and cultural-linguistic paradigms by examining studies of human cognition, affect, and behavior. In doing so, it likewise prepares the stage for a brief discussion of theological implications at the end. Although the empirical study of experience—and religious experience in particular—is ripe for theological reflection, a word of caution is in order. Many pertinent theological issues are matters of speculation that resist definitive adjudication through empirical analysis. Still, the revised experientialist position offers a better starting point for theological reflection than either the cultural-linguistic or experiential-expressivist paradigms.

"Experience" according to Liberalism and Postliberalism: Critique and Synthesis

There are four basic principles to keep in mind during the following discussion of experience. First, experiences are undergone. In other words, an experience is something that happens to a person.

Psychologically speaking, an experience consists of mental (e.g., cognitive, affective, sense perceptive) and/or behavioral activity.[12] Second, experiences are "roughly datable."[13] In other words, they typically have a beginning and end, although these might not be so clearly defined.[14] Third, experiences have a source. Source characteristics affect a person's cognitive, affective, and/or behavioral activity. Finally, experiences are affected by the aptitudes/characteristics of the persons who have them. Thus, two people can have experiences instigated by the same thing that differ in cognitive, affective, or behavioral terms. For instance, an individual with normal vision and one with red-green color blindness may have different experiences of seeing a "red" apple. According to this example, both experiences have the same source, but they differ in cognitive terms.[15] Similarly, American and Chinese individuals may have different experiences of a dragon after being asked to think about one, due to the fact that they have undergone different socialization processes that (generally) equip them with beliefs about dragons as being evil or lucky, respectively.[16]

By and large, the liberal position discussed above fails to acknowledge the fact that individuals possess different aptitudes/characteristics that can affect experiential processing. This recognition is a postliberal, that is, cultural-linguistic, achievement.[17] Liberals (experiential-expressivists) have argued that separate persons faced with same/similar stimuli will have the same experience but (perhaps) interpret it differently.[18] The problem with the conventional liberal view is that it is markedly ignorant about the ways that humans receive and process information. In perceiving physical stimuli or thinking about a particular subject, for example, the mind-brain is involved. Unless separate humans were to have identical minds/brains, their experiences could not be the same even though the same stimulus was present.[19] In short, all experiences are mediated.

Furthermore, experiences are interpreted. People react to discrete experiences with cognitive, affective, or behavioral activity. This reaction to a given experience constitutes an interpretation. Interpretations are like secondary experiences because they also involve cognitive, affective, or behavioral activity. Due to this similarity and the fact that interpretations naturally follow experiences, differentiating between interpretation and experience can be difficult or even idiosyncratic. Furthermore, some postliberal scholars will claim that all experiences "come interpreted," by which they mean "mediated" by the individual's prior psychological resources (see above).

Although postliberal scholars were correct in claiming that all experiences are mediated, this claim has been the subject of unfortunate and insufficient framing attempts that leave the impression that different people necessarily have different—rather than similar—experiences when they are faced with the same or similar stimuli. There are at least two problems with postliberal theory—à la Lindbeck, in particular—that lead to this impression.[20] First, postliberals like Lindbeck narrowly focus on culture, language, and religion as the main "ingredients" that shape people's minds.[21] Hence, Lindbeck and his sympathizers use the phrase "cultural-linguistic" to describe their methodology.[22] Furthermore, they have tended to view cultures, languages, and religions in their totality, which consequently highlights their distinctiveness.[23] Second, Lindbeck, in particular, has assumed that the mind is essentially "raw material" to begin with.[24] Given these presuppositions, it is not surprising to find postliberals, such as Lindbeck, ignoring experiential similarities or assuming them to be coincidental or trivial.

While postliberals are correct in an absolute sense—different people have different experiences—the amount of similarity between people's experiences can be striking. In fact, some accounts of experience across cultures/religions are so similar that it is nearly impossible to detect a meaningful difference (see below).[25] Thus, the liberal leaning toward experiential similarity must be recovered without losing the postliberal emphasis on mediated experience. The revised experientialist position does both by relying on basic assumptions of cognitive science.

In brief, cognitive scientists assume that the mind-brain (1) is shaped by environmental conditions and (2) possesses a generic structure as well as inherent (e.g., genetic) predilections and limitations.[26] The second assumption contradicts the postliberal notion of the mind as "raw material." Humans possess certain basic capacities and potentialities by virtue of being human. The first assumption posits a broader reality than culture (or "culture on the ground") as the basis of psychological conditioning.[27] Furthermore, cognitive scientists assume that the various environments

in which humans find themselves share many general properties without necessarily being identical.

If each of these assumptions is correct, we should expect to find quite similar cross-cultural experiences in the areas of cognition, affect, and behavior. Each of the following sections dealing with these areas will bear out our expectations. By relying so directly upon empirical findings from the social sciences, my methodology can be distinguished from those typically grounding experiential-expressivist or cultural-linguistic ideologies (of which, the former are more often indebted to metaphysics and existentialism, while the latter generally rely on philosophy of language and epistemology).[28] Furthermore, the following review of cognition, affect, and behavior studies will deepen our understanding of religious experience, in particular, and ground a brief discussion of theological issues associated with the nature of religious experience.

Cognition

Despite some variations among the environments where people live, there are a host of environmental aspects that remain constant for all human communities. For example, all of them contain living and nonliving things. These things behave according to generic laws or principles. Nonliving things such as rocks are inert and will not move unless some external force is applied to them, whereas animals (a special class of living things) are self-propelled. Understandings such as these are not limited to any one cultural group but appear to be recognized universally on account of environmental similarity in the places where people develop. Cognitive scientists have documented a compendium of common human beliefs/understandings that apply to natural and supernatural/spiritual things.[29] This strongly suggests that people from various cultural backgrounds have many of the same *types* of experiences—these experiences generate the beliefs in the first place.

With regard to cultural variation, cognitive scientists are not in doubt. Humans possess cultural knowledge (knowledge particular to one or a few cultural groups) in addition to more general knowledge about things. While it is important to acknowledge culturally diverse forms of knowledge and related experience, it is at least equally important to recognize that cultural diversity occurs within a broader context of environmental similarity. Hence, at the same time as persons from one culture are developing knowledge specific to their culture, they are also forming beliefs/ideas that people from other cultural backgrounds will develop as well.

Furthermore, many seemingly distinct cultural concepts or beliefs make use of more general ones. God concepts provide a good example to consider. There are a variety of God concepts, such as Jesus, Shiva, Allah, and Yahweh, and each of these has representations that differ between individuals and groups. Although each of these "concepts" is distinct—for example, Jesus is distinct from Shiva and one person's Jesus is distinct from another person's Jesus—they are predicated on many, but not all, of the same principles.[30] Thus, each of the aforementioned God concepts and their individualized representations refer to minimally counterintuitive intentional agents possessing strategic information.[31] These and other similarities between distinct God concepts are again supportive of common human experiencing. Whether an individual thinks of Jesus or Shiva, his or her experience would likely entail many of the same cognitive notes.

Additionally, it is evident that the same types of phenomena facilitate thinking about God concepts across cultures.[32] For example, both Christians and Hindus tend to think of divine agents if they encounter some type of anomalous event such as dream fulfillment.[33] The fact that the same type of event is implicated in the cognitive activities of both persons further suggests that the total experiences of both persons are similar in this case.

In short, cross-cultural studies of cognition show that some beliefs are widely dispersed and triggered by characteristic phenomena. Shared beliefs are not necessarily superficial commonalities; rather, they can provide the basic scaffolding for more complex/specific cultural ideas.[34] Thus, two individuals might have separate experiences—involving distinct cultural concepts—that nonetheless overlap in fundamental ways. At base, the presence of cross-cultural beliefs suggests that diverse persons sometimes have similar experiences.

Affect

Affect, or feeling, represents another crucial aspect of experience. Empirical (non-anthropological) investigations of affect generally suggest that affect is

more similar than different cross-culturally.[35] In one study, for example, Jeanne Tsai and her colleagues asked European and Hmong American participants to "relive past episodes of intense happiness, pride, love, anger, disgust, and sadness."[36] While the observed behavior in relation to a particular prompt sometimes differed between groups, the electrodermal responses were "strikingly similar."[37] The latter finding suggests that the two groups were essentially having the same affective experiences, whereas the former may suggest that they had developed different means of interpreting their experiences.[38]

Tsai has since developed the concepts of "actual" and "ideal" affect.[39] Actual affect refers to what persons *actually* feel in the moment of experience, whereas ideal affect refers to what persons *want to* experience and provides a way of *interpreting* what they do, in fact, experience.[40] Tsai and her colleagues claim that "culture shapes ideal affect more than actual affect."[41] It is important to note that in making this statement these researchers do not deny the possibility of some cultural shaping of actual affect. At the same time, they do not want to lessen the fact that feelings tend to have a great degree of overlap between cultures, such that it is possible to speak of generic affective traits such as love, anger, disgust, and others.

In some ways, the conclusions of Tsai and her colleagues fail to compute with either the experiential-expressivist or cultural-linguistic models of experience. On the one hand, a rigid experiential-expressivist model—which assumes cross-cultural invariance at the level of pre-reflective experience—is rebuffed by the likelihood of subtle qualitative differences in original affect.[42] On the other hand, a rigid cultural-linguistic model fails to appreciate the profound degree of similarity.[43] The revised experientialist model handles the actual state of affairs better than either of these models by forthrightly claiming that human emotional states are generalizable on account of common human conditioning while being susceptible to limited modification as a consequence of cultural, linguistic, or religious peculiarities. By and large, then, the basic notes of affective experience remain the same for diverse persons, but they probably differ in precise tone.

Mystical Experience

If the above model of affective development and differentiation is legitimate, then one would expect it to apply to mystical experience—or "mystical states of consciousness"—which, as William James has noted, are "more like states of feeling than like states of intellect."[44] Despite individual conceptualizations, there seems to be broad scholarly consensus that mystical experience is a kind of "peak" religious experience, with characteristics analogous to the experience of salvation as described by various religious traditions.[45] In line with our previous discussion, however, scholars and theologians are divided as to the degree of cross-religious similarity. On one end are those who support or otherwise imply that mystical experience is uniform across religious groups (religion may yield differences in interpretation but not experience), while the opposite end consists of those who argue that mystical experience differs for different individuals and groups.[46] For theologians and religious scholars, the payoff for each of these conclusions rests in the relative uniqueness of individual religious traditions as well as the implied reference/source of the experiences themselves (see below).

As noted above, all experiences are mediated by the mind-brain. Mystical experience is a good case in point: several studies have linked distinctive neurological activity to putative mystical experience.[47] While the neurological mediation of experience problematizes extreme conceptualizations of experiential uniformity, research on diverse religious adherents attaining mystical or peak consciousness suggests that many of the same brain regions and patterns of activity are operative across individuals and groups.[48] These studies provide one line of evidence that different religious persons can have similar religious experiences but refer to them by different names.

Other lines of evidence that support the same conclusion derive from phenomenological and psychological analyses of mystical experience. While there are various phenomenological analyses of mystical experience, one of the most influential has been that of Walter Terence Stace.[49] Based on analysis of "mystical" or "peak" experience reports from separate religious adherents, Stace systematically identified several characteristics common to these individuals and traditions. These include positive affect (e.g., joy, peace), religious affect (e.g., sacredness, awe), noesis, ineffability, timelessness/spacelessness, ego loss, inner subjectivity (the sense

of life in nonliving/non-agential things), and unity with something(s) beyond the self.[50] Furthermore, Stace claimed to discern two "species" within a single mystical "genus."[51] The genus is defined by oneness/unity whereas the species correspond to the ways in which that oneness/unity is realized. Introvertive mysticism refers especially to a unitary consciousness whereas extrovertive mysticism corresponds with a feeling of oneness/unity with things outside the self.[52] Each of these experiential "species," according to Stace, has precedence in each of the world's major religious traditions and communities, although it may be the case that some traditions stress one type over another.[53] Ultimately, Stace was compelled to conclude that the evidence for unanimity of mystical experience across religiocultural boundaries was quite strong indeed. According to him, any differences between individual/communal ways of describing the experience or attributing meaning to it were due to secondary interpretation upon what is a primary, unreflected (i.e., not a culturally mediated) experience.[54]

Empirically speaking, there is fairly strong support for Stace's phenomenological deductions. Ralph Hood and his colleagues have operationalized each of Stace's eight categories for survey research. To date, the resultant M Scale has been tested among Christians, Hindus, Buddhists, Muslims, and Jews (hailing from various sects and geographical locations).[55] Responses to the scale in each of the test sites indicate that each of the eight characteristics resonates with the experiences of the local population as a whole. Furthermore, group response rates are similar, according to studies that sought to compare two or more religious populations. Additionally, participants in one non-Western study were interviewed with the survey items to see whether they were applicable to real experiences.[56] The results were affirmative, providing further construct validity for each of Stace's eight characteristics. All of the above suggests that Stace's basic characteristics of mystical experience are generally applicable.

Cross-cultural investigations of the M Scale have also been factor analyzed.[57] Typically, these analyses reveal three factors. Two of these factors generally contain traits that suggest introvertive or extrovertive classification, while a third factor contains additional traits, usually classified under the rubric of "interpretation." In other words, different religious communities tend to associate the components of their mystical experiences in same or similar ways.

So what can we conclude from this empirical investigation? At a minimum, we should conclude that a set of largely affective constructs/characteristics applies more or less equally to the extraordinary experiences of people from various backgrounds. In addition, these characteristics seem to possess logical interrelationships mostly independent of cultural/religious influence. At both trait and factor levels, mystical experience appears to be similar across religiocultural groups. Based on this analysis, I will, however, stop short of claiming that mystical experiences are entirely the same. After all, some differences in the results of factor analysis have been documented, and it remains possible that the same trait could refer to qualitatively different—albeit related—feelings. There might also be other unexplored or trivialized aspects of mystical experience that are present in the experiences of one group and entirely or largely absent from the experiences of others.

Ultimately, this brief foray into mystical experience is consistent with what I have argued in the prior section on "Affect." The basic notes of mystical experience—like other forms of affect—transcend individuals and groups. While this does not negate cultural/religious shaping of mystical experience, it does suggest that mystical experience can be "shared" to a broad degree—a finding of interest to psychologists and anthropologists as well as theologians.[58] Theologians are eminently concerned with the (metaphysical) source of mystical experience. As to whether mystical experiences of different religious persons point to the same source, I will offer a few related considerations in the section on "Theology of Religions." In anticipation of that discussion, it is prudent to note that the plausibility of separate religious persons reacting to the same source rises with the extent of similar or seemingly identical experiential characteristics. Valid assessment of the latter is made possible by the detail of comparative findings and analysis. The just-reviewed research on mystical experience across religions certainly does not negate the possibility of a single metaphysical ground for such, but it does not confirm the possibility beyond all reasonable questioning either.

Behavior

In conjunction with previous investigations of cognition and affect, the following brief examination of behavior supports the notion that experience can be shared across cultural and religious groups. As noted above, behavior can be seen as a kind of interpretation of affective experience stemming from the mind-brain.[59] However, behavior can also be viewed as a kind of embodied experience in itself. Regardless, evidence of similar behaviors across people groups is highly suggestive of the notion that their experiences share much in common.

With regard to putatively religious behaviors, anthropologists have noted cross-cultural/religious similarities especially with regard to glossolalia and possession.[60] Striking from my perspective as a charismatic-leaning Christian are several descriptions of ecstatic behavior from writers of Hindu sects. For example, Rupa Gosvami, a sixteenth-century Gaudiya Vaishnavite, describes the types of behavior often manifested by those enthralled with Krishna as "dancing, rolling around, singing, crying out, contorting the body, roaring like an animal, yawning, panting, disregarding worldly people, salivating, laughing loudly, shaking, and hiccupping."[61] Several centuries earlier, a Shaivite text, *The Kaula Ocean of Waves*, lists the following behaviors typical of the experience of spiritual power: "spontaneous laughter […] horripilation, 'paralysis,' convulsion, acting as if drunk."[62] In the mid-twentieth century, a treatise by Swami Visnu Tirtha echoes several of the aforementioned behavioral signs in its description of activated *kundalini*:

> Your body begins trembling, hair stand on roots, you laugh or begin to weep without your wishing, your tongue begins to utter deformed sounds […] your speech begins to utter sounds like those of animals, birds and frogs or of a lion … you feel intoxicated without taking any drug.[63]

Many of these signs endemic to Hindu religious experience would not be uncommon at a modern Pentecostal revival. For example, a 1990s revival at the Toronto Airport Christian Fellowship (formerly Toronto Airport Vineyard) witnessed the following behaviors among its participants: spontaneous "holy laughter," "being drunk in the Spirit," "roaring like a lion," "weeping," "shaking," "dancing," and "speaking in tongues."[64] The similarity in terms/behavior between the Christian and Hindu accounts is impossible to miss. Hence, it is tempting to conclude that the overall experiences represented by these behaviors would be largely the same. In other words, cross-cultural accounts of behavior suggest that certain general forms of religious experience transcend demographic boundaries.

Summary

The foregoing review of cognition, affect, and behavior shows that individuals sometimes have quite similar (religious) experiences despite belonging to different cultural, religious, and linguistic groups. Nevertheless, cross-cultural analysis of experience can uncover salient features belonging to one or another group. Even highly similar cross-cultural experiences are probably not identical, due to differences between the minds of the people processing them. Altogether, this state of affairs challenges the prevailing experiential-expressivist and cultural-linguistic models of experience, while lending support to the revised experientialist paradigm.

Contra experiential-expressivism, the revised experientialist position claims that all experiences are mediated. Contra the cultural-linguistic model, the revised experientialist position asserts that the mind is influenced by common human and environmental conditions. Put another way, the mind is not raw material to begin with, and culture, language, and religion are insufficient variables to explain how minds are shaped. Lindbeck, a prominent supporter of the cultural-linguistic paradigm, has argued that one's theological methodology must be able to "handle the anthropological, historical, and other nontheological data better than do the alternatives" in order for it to be viable.[65] If that is the case, then a revised experientialist paradigm ought to be the basis for theological reflection instead of the cultural-linguistic or experiential-expressivist options.

Implications

As stated earlier, liberal (experiential-expressivist) and postliberal (cultural-linguistic) understandings of experience seem to be correlated with different positions on topics of theological interest. I will briefly address two of these topics—interreligious dialogue and the theology of religions—and the way(s) in which our revised understanding of religious experience may impact discussions concerning these. With regard to interreligious dialogue, our revised experientialist understanding clarifies the

basis of shared assumptions (which underwrite the possibility of mutual intelligibility) while being consistent with a basic understanding of natural revelation. With regard to theology of religions, I discuss how the revised experientialist understanding offers rationale for a more cautious theological approach such as that being demonstrated under the relatively new discipline of comparative theology. In addition, I suggest how the revised experientialist understanding offers a corrective to cultural-linguistic ways of thinking about the Trinity and salvation. In line with these discussions, I will also address the crucial issue of discerning a metaphysical ground for religious experiences.

Interreligious Dialogue

Critics of the postliberal school of thought—and to some degree Lindbeck himself—have noted that the cultural-linguistic perspective provides a weak rationale for interreligious dialogue. In essence, this perspective begets a concern that experience (and the knowledge thereby gained) is radically contextual and therefore cross-religious discussion is not likely to entail common understanding or agreement.[66] Thus, instead of bringing religions together in a way that would potentially enhance mutual respect, interreligious dialogue may fail in this regard and perhaps even lead to increased suspicion of the other.[67]

Although radical sectarianism may be more of a temptation for those who favor cultural-linguistic theory as opposed to experiential-expressivism, actual proponents of cultural-linguistic theory are somewhat less radical than their critics often make them out to be. Despite the fact that Lindbeck is committed to anti-foundationalism and the religions-as-language-games analogy, he briefly affirms "universal norms of reasonableness."[68] In a somewhat similar vein, Placher claims that different religions share assumptions.[69] Given this state of affairs, dialogue could lead to some degree of agreement and understanding between religious persons. Unfortunately, Lindbeck and Placher do not sufficiently articulate how distinct religious persons might come to possess the same norms of reasonableness. In fact, it is difficult to see how the cultural-linguistic paradigm could support this state of affairs given its rather closed understandings of culture, language, and religion.

The basic assumptions of the revised experientialist perspective help explain what Lindbeck and others want to affirm, namely, shared beliefs/norms of reasonableness.[70] To reiterate, common genetic and environmental conditions persist in spite of cultural, religious, or linguistic difference. Hence, persons develop many of the same beliefs/norms of reasonableness. Some of the beliefs that people share seem to undergird more particular religious beliefs and/or be joined together in systems with such beliefs.[71] Thus, even conversations regarding particular elements of a belief system may involve or imply more-generally accepted beliefs. As a consequence, different religious persons can describe their beliefs or reasons for a particular kind of stance or behavior and find that they share elements in common. Furthermore, after finding that they share elements in common, participants of interreligious dialogue may be challenged to reconsider the efficacy, necessity, or reasonability of their belief structures.[72] This could lead to epistemic change or conversion. After all, "if someone who shares my basic beliefs is able to believe that, why shouldn't I as well?"

In short, the problem with cultural-linguistic theory vis-à-vis interreligious dialogue is that it fails to specify how persons affiliated with distinct cultures and religions might be able to share assumptions. Simply stating the fact that people "happen" to share assumptions begs the question as to why they share assumptions in the first place.[73] The revised experientialist theory provides an answer. Again, common genetic and environmental conditions persist in spite of cultural, religious, or linguistic difference. With regard to the environment in particular, there are near-universal elements present in the various places where people live in addition to elements with a more limited or fixed distribution. Thus, even though people live in separate environments, there are elements from those environments that will overlap and provide grounding for shared beliefs. Religions—or religious belief systems—are not entirely closed off from one another because they are shaped by environmental conditions that they have in common.

Before transitioning, it seems pertinent to offer a brief theological commentary on some of the issues that have been raised in this section. From a perspective that claims Christians generally possess a plurality of divine truth, the presence of shared beliefs between

Christian and non-Christian religious traditions/communities suggests that the latter possess some of that truth or "ray[s] of that truth."[74] Additionally, the observation that shared beliefs are the product of common environmental features bridging Christian and non-Christian communities is consistent with a basic understanding of natural revelation provided that nature is not simply understood as "the great outdoors" but instead as everything that surrounds the individual. Furthermore, the fact that Christians and non-Christians do not share all of the same beliefs (when it comes to God or Reality or whatnot) accords with the idea that generally available revelation from nature fails to provide a complete or sufficient understanding of God. To acquire the latter, one must be exposed to special revelatory conditions, which, from a Christian perspective, would be unique characteristics of the Christian community as a sociological whole. Interreligious dialogue between Christians and non-Christians would expose the latter to some of that additional revelation, but momentary encounters with Christians would generally have less of an effect on one's belief system than prolonged participation within the Christian community.[75]

Theology of Religions

Earlier discussions noted stark differences between experiential-expressivist and cultural-linguistic theologians. The former generally assume that peak or fundamental religious experiences of different religious persons are essentially the same. The latter claim that religious experiences are always mediated by individuals who have been shaped by the particulars of their communities. Implicit within this cultural-linguistic perspective is an expectation for difference at the level of experience. While technically legitimate, the expectation can lead to simply writing off separate experiences as different without dutifully examining them for commonality (see below). As I have endeavored to show, there are good theoretical and empirical reasons for expecting some commonality between religious communities regarding the experiences of their members. This, I hope, would encourage theologians to spend more effort on initial comparison of religious experiences in anticipation of theological reflection. In fact, the relatively new discipline of comparative theology stresses this need for thick description and analysis of divergent religious practices and experiences.[76] This discipline represents an important development within theology of religions, although—in conjunction with some of its sympathetic critics—I hope it will come to include more ethnographic and psychological comparisons to balance out its major reliance on religious texts at present.[77]

With regard to cultural-linguistic theory and the theology of religions, Mark Heim has produced some of the most provocative and influential work.[78] In true cultural-linguistic fashion, Heim asserts that different religious persons have different religious experiences by virtue of distinctive sociocultural influences. More provocatively, Heim argues that communally distinct religious experiences have eschatological variants; in other words, differential religious socialization yields different experiences for Christians, Buddhists, Hindus, et cetera in the present life and in the life to come. The experiences of Christians, Buddhists, and others in the life to come represents a fulfillment of their religious values and aspirations, which have a similar—although less dramatic—effect on the experiences of such people at present. To account for experiential differences between the religions theologically, Heim relies on Trinitarian concepts. Thus, different religious experiences are the product of different relationships with the Trinity and its interrelationships. Different religions afford their adherents different relationships with the Trinity.

Although Heim's proposal has been widely regarded as ingenious (albeit speculative), I have a few concerns. First, detailed empirical comparisons of religious experience are simply lacking in Heim's work, although there are some fairly rudimentary comparisons of religious experience/"salvation" experience that appear to be based on scriptural sources. Like other cultural-linguistic theologians, Heim says that interreligious difference vis-à-vis religious experience is "plainly to be observed,"[79] thus eliminating the need for detailed comparison and evaluation of commonality. Had Heim engaged in extensive comparisons of religious experience, he may have altered his depiction of the Trinity. His insistence on interreligious difference results in a depiction that emphasizes uniqueness among the members of the Trinity and their relations to one another.[80] As we have seen, however, commonality between religious experiences can be broad and impressive. If Heim had taken this into consideration

when describing the Trinity, the final description ought to have placed greater emphasis on oneness/unity, which, coincidentally, would have made it more consistent with orthodox Trinitarianism.[81]

In spite of this first critique, I wonder why one should assume that religious experiences of non-Christians, in particular, are grounded in the Trinity? Although the probability of a single divine entity/reality grounding the religious experiences of diverse persons seems to rise with the extent of shared experiential features, there are biblical and analytical considerations that suggest caution before claiming a single source for cross-cultural experience. For example, the New Testament claims that Satan disguises himself as an angel of light (2 Cor. 11:14). Although cryptic, the idea seems to suggest that separate spiritual entities can be mistaken as a single entity. Additionally, portions of the Old Testament seem to support a henotheistic kind of worldview.[82] According to this view, there are multiple divine entities, including one—Yahweh, the God of the Israelites—who far surpasses the rest. Even though Yahweh is exceptional, the fact remains that there are additional entities whose qualities are similar enough to Yahweh that they are likewise regarded/apprehended as gods. According to this view from scripture, it would seem that multiple entities are capable of eliciting comparable religious experiences. Thus, separate cases of "roaring like a lion," irrepressible laughter, feelings of drunkenness, and others could be the product of separate spiritual entities/sources, which is implied by the unique interpretations that Christians and Hindus give to these events. Again, however, these separate spiritual entities/sources would need to possess sufficiently similar characteristics in order for their effects on humans to be generally consistent.

In truth, this alternative view that I have been describing is not very common among contemporary theologians and stands in need of further elaboration.[83] Seemingly more common among theologians—whether they ascribe to cultural-linguistic or experiential-expressivist methodologies—is the idea that one God is responsible for the experiences of diverse people.[84] Neither of these ideas need be mutually exclusive, however. Some religious experiences attributed to separate entities may derive from the same entity, while others derive from separate entities. Furthermore, there is a possibility that both ideas are wrong—religious/mystical experiences are purely the product of human potential and natural stimuli.[85] Religious/mystical experiences purported to be about God(s) may have evidential force in arguments for the existence of such entities, but the existence of such cannot ultimately be proven.[86]

While a variety of issues are germane to theology of religions, much of the discussion historically has concerned the issue of salvation. In particular, the following question engenders debate among Christians: will non-Christians be saved? Working from the perspective that salvation is a kind of experience, prominent cultural-linguistic theologians have argued "no."[87] Consistent with their views about the cultural/religious shaping of experience, these authors argue that if salvation is something that Christians experience, one must be Christian to experience it. Still, non-Christians might have other eschatological experiences that are variously blessed, but these will differ in quality from the Christian experience; hence, non-Christians cannot be considered "saved" in the Christian sense.[88]

I will finish this discussion with a few comments in regard to the cultural-linguistic understanding of salvation. Assuming, as we have argued, that people are indeed shaped by culture, language, religion, and a host of other particularizing factors, it is certainly possible that eschatological experiences (e.g., "salvation") will be different for everyone. This possibility applies to Christians as well, since each individual Christian is unique. It may be that all Christians will experience something that, at the end of days, non-Christians do not; and yet, even among Christians, qualitative experiential differences could persist as long as their individual personhoods remain intact.

Still, one has to wonder whether differences between Christians and others with regard to their (possible) eschatological experiences of the Blessed are really significant. Our previous survey of religious experiences suggests that people of disparate backgrounds can have experiences that are overwhelmingly similar or basically the same. Logically speaking, this situation seems to occur when disparate peoples encounter the same object or separate objects that are similar. Experiencing God in his eschatological splendor could be basically the same for anyone who has the good grace to be placed in some sort of direct relationship with God at the end of days.[89] Ultimately, this statement points to grace as the essential entryway to salvation or to a salvation-

like experience. The major determiner of the quality of one's eschatological experience seems not to be personal background; rather, it is God's presence—and God can (arguably) choose those to whom he will make himself known. Perhaps God looks on Christians with special favor in meting out eschatological scenarios. And yet, perhaps God will choose to make himself known to non-Christians in the same way he makes himself known to Christians. Although God's selection process is shrouded in mystery, we can be fairly confident that those given the same degree of access to God will have very similar experiences, regardless of their past choices and religious conditioning. ✠

Notes

[1]David Tracy, *Blessed Rage for Order: The New Pluralism in Theology* (Chicago, IL: University of Chicago Press, 1996).

[2]Karl Rahner, "The Experience of God Today," in *Theological Investigations*, vol. 11 (New York: Seabury Press, 1974), 149–65; ___, "Experience of the Spirit and Existential Commitment," in *Theological Investigations*, vol. 16 (New York: Seabury Press, 1979), 24–34; ___, "Experience of Transcendence from the Standpoint of Catholic Dogmatics," in *Theological Investigations*, vol. 18 (New York: Crossroad Publishing, 1983), 173–88; ___, "Experience of the Holy Spirit," in *Theological Investigations*, vol. 18, 189–210.

[3]George A. Lindbeck, *The Nature of Doctrine: Religion and Theology in a Postliberal Age*, 25th anniversary ed. (Louisville, KY: Westminster/John Knox Press, 2009), 16.

[4]Gerald R. McDermott and Harold A. Netland, *A Trinitarian Theology of Religions: An Evangelical Proposal* (New York: Oxford University Press, 2014).

[5]Lindbeck, *The Nature of Doctrine*, 130.

[6]See William C. Placher, *Unapologetic Theology: A Christian Voice in a Pluralistic Conversation* (Louisville, KY: Westminster/John Knox Press, 1989).

[7]For example, see Placher, *Unapologetic Theology*; Richard Lints, "The Postpositivist Choice: Tracy or Lindbeck?," *Journal of the American Academy of Religion* 61, no. 4 (1993): 655–77; Bruce D. Marshall, ed., *Theology and Dialogue: Essays in Conversation with George Lindbeck* (Notre Dame, IN: University of Notre Dame Press, 1990).

[8]Tracy, *Blessed Rage for Order*, compare chaps. 4 and 8 especially.

[9]Placher, *Unapologetic Theology*, 61ff.

[10]McDermott and Netland, *A Trinitarian Theology of Religions*, 8, 90ff.

[11]This statement is not meant to be a strong indictment against the assumptions, methods, and conclusions of the authors mentioned, even though I harbor some criticism and/or questions concerning each of the authors' methodologies. I am generally supportive of multidisciplinary or interdisciplinary research toward a specific end.

[12]The mind and behavior are the two principle subjects of psychology. See Jay Friedenberg and Gordon Silverman, *Cognitive Science: An Introduction to the Study of Mind*, 3rd ed. (Thousand Oaks, CA: Sage, 2016), 58ff. If the individual person is the locus of (human) experience, then it would also be possible to define experience biologically as the things that take place in the brain and other material systems of the human body. I am certainly not against this definition; rather, I find it complementary to the psychological one presented above. It is widely accepted that psychological activities such as cognition and affect have biological correlates. Thus, for example, when someone feels "angry" or visualizes an object in the mind, these psychological activities/experiences are accompanied by particular neuronal activity. In what follows, I divide my study of experience into cognitive, affective, and behavior sections. Although one might argue that sense perception is given short shrift under this breakdown (in fact, Breckler [1984] categorizes sense perception as a cognitive activity), it seems to cover many of the things that scholars and laity refer to when they describe experience. Interestingly, cognition, affect, and behavior have received empirical validation as distinct but interrelated components of attitude. See Steven J. Breckler, "Empirical Validation of Affect, Behavior, and Cognition as Distinct Components of Attitude," *Journal of Personality and Social Psychology* 47, no. 6 (1984): 1191–205. "Attitude" and "experience" are extensively overlapping concepts. Cf. Breckler, "Empirical Validation"; Friedenberg and Silverman, *Cognitive Science*, 341–43.

[13]These first two principles of experience are succinctly discussed by Caroline Franks Davis in her work *The Evidential Force of Religious Experience* (Oxford: Clarendon Press, 1989), 19–20. A study of her work indicates that she would agree with the last two principles as well.

[14]The experience of (ultimate/post-mortem) salvation may have a roughly datable beginning without an end (see final section on "Theology of Religions").

[15]See note 12 above.

[16]I owe this example to James Peterson.

[17]See Lindbeck, *The Nature of Doctrine*, especially p. 130.

[18]Ibid.

[19]For more on the mediation of experience, see Franks Davis, *The Evidential Force of Religious Experience*, 143–65.

[20]In what follows I am largely relying on Lindbeck's seminal work, *The Nature of Doctrine*. Lindbeck is often regarded as one of the founders and cardinal representatives of postliberalism. Although the problems with his theory—as expressed in *The Nature of Doctrine*—may be less apparent in the works of later scholars, there is no question that his theory casts a long shadow over the postliberal movement in theology. See Bruce D. Marshall, "Introduction: *The Nature of Doctrine* after 25 Years," in Lindbeck, *The Nature of Doctrine*; also see Lints, "The Postpositivist Choice."

[21]Lindbeck, *The Nature of Doctrine*; also see Placher, *Unapologetic Theology*.

[22]For a detailed description of the "cultural-linguistic" method, see Lindbeck, *The Nature of Doctrine*, especially chaps. 1 and 2. Lindbeck's sympathizers include William Placher, Kenneth Surin, and Amos Yong, among others. See Placher, *Unapologetic Theology*; Kenneth Surin, "'Many Religions and the One True Faith': An Examination of Lindbeck's Chapter Three," *Modern Theology* 4, no. 2 (1988): 187–209; Amos Yong, *Hospitality and the Other: Pentecost, Christian Practices, and the Neighbor* (Maryknoll, NY: Orbis Books, 2008), 50–53.

[23]Consider the following statement by Lindbeck in *The Nature of Doctrine*:

> It is just as hard to think of religions as it is to think of cultures or languages as having a single generic

> or universal experiential essence of which particular religions—or cultures or languages—are varied manifestations or modifications. One can in this outlook no more be religious in general than one can speak language in general. Thus the focus is on particular religions rather than on religious universals and their combinations and permutations. (p. 9)

Additionally, Lindbeck and other postliberal scholars frequently employ the Wittgensteinian phrase "forms of life" to emphasize both the uniqueness and boundedness of cultures, languages, and religions. Cf. Lindbeck, *The Nature of Doctrine*, 3, 118; Placher, *Unapologetic Theology*, 55–73; Yong, *Hospitality and the Other*, 52.

[24]Lindbeck, *The Nature of Doctrine*, 130.

[25]Perhaps cases such as these led liberals to assume that different people were having the same experiences to begin with (even though this deduction is incorrect).

[26]See Justin L. Barrett, *Why Would Anyone Believe in God?* (Lanham, MD: AltaMira Press, 2004); Steven Pinker, "Why Nature & Nurture Won't Go Away," *Daedalus* 133, no. 4 (2004): 5–17.

[27]The term "culture on the ground" refers to cultural manifestations that human persons can perceive/detect. The counterpart to this term is "culture in the mind," which refers to cultural or culturally influenced schemas. Culture in the mind and culture on the ground are influenced by each other. Both terms derive from the following: Bradd Shore, *Culture in Mind: Cognition, Culture, and the Problem of Meaning* (New York: Oxford University Press, 1996).

[28]Compare, e.g., the following: Tracy, *Blessed Rage*; Rahner, *Theological Investigations*; Placher, *Unapologetic Theology*; Fergus Kerr, *Theology after Wittgenstein*, 2nd ed. (London: SPCK, 1997); John Allan Knight, *Liberalism versus Postliberalism: The Great Divide in Twentieth-Century Theology* (New York: Oxford University Press, 2013). One of the novelties of Lindbeck's approach—contra the experiential-expressivists—is his stated commitment to "anthropological" and other forms of empirical inquiry. Nonetheless, his engagement with these forms of inquiry is both general and thin (see *The Nature of Doctrine*, chap. 2). Likewise, William Placher has a chapter on anthropology in his defense of postliberalism, but the actual discussion quickly turns to Wittgenstein and his concept of "language games" (see *Unapologetic Theology*, 55–73).

[29]Justin L. Barrett, *Cognitive Science, Religion, and Theology: From Human Minds to Divine Minds* (West Conshohocken, PA: Templeton Press, 2011); Robert E. Sears, "Spiritual Dreams and the Nepalese: Attribution Theory and the Dream-Related Cognition of Nepali Christians and Hindus," PhD diss., Fuller Theological Seminary, School of Intercultural Studies, 2016.

[30]In using the term "concepts" to describe Jesus, Shiva, and other God(s), I am not intentionally denying their actual/historical reality. Jesus, for example, was/is a person, while at the same time "Jesus" exists as a concept within individuals' minds.

[31]Additionally, Barrett claims that God concepts generally refer to agents that motivate religious behavior and act in the human world in detectable ways. See Justin L. Barrett, "Why Santa Claus Is Not a God," *Journal of Cognition & Culture* 8, no. 1/2 (2008): 149–61.

[32]For descriptions and examples of relevant phenomena, consult the following: Sears, "Spiritual Dreams and the Nepalese"; Barrett, *Why Would Anyone Believe in God*; Ann Taves, *Religious Experience Reconsidered: A Building-Block Approach to the Study of Religion and Other Special Things* (Princeton, NJ: Princeton University Press, 2009).

[33]Sears, "Spiritual Dreams and the Nepalese," 187–99.

[34]Research on "God concepts" suggests this. Also see Barrett, *Cognitive Science, Religion, and Theology*.

[35]Jeanne L. Tsai, Birgit Koopmann-Holm, Masako Miyazaki, and Camaron Ochs, "The Religious Shaping of Feeling: Implications of Affect Valuation Theory," in *Handbook of the Psychology of Religion and Spirituality*, 2nd ed., ed. Raymond F. Paloutzian and Crystal L. Park (New York: The Guilford Press, 2013), 276.

[36]Jeanne L. Tsai, Yulia Chentsova-Dutton, Liliana Freire-Bebeau, and Diane E. Przymus, "Emotional Expression and Physiology in European Americans and Hmong Americans," *Emotion* 2, no. 4 (2002): 380.

[37]Tsai et al., "Religious Shaping of Feeling," 276; cf. Tsai et al., "Emotional Expression," 380–97.

[38]Tsai et al., "Religious Shaping of Feeling," 276–77.

[39]Jeanne L. Tsai, "Ideal Affect: Cultural Causes and Behavioral Consequences," *Perspectives on Psychological Science* 2, no. 3 (2007): 242–59; Tsai et al., "Religious Shaping of Feeling," 274–91.

[40]Ibid., 276–77.

[41]Ibid., 277ff.

[42]Compare with Lindbeck, *The Nature of Doctrine*, 22–23, 25–26. It is reasonable to expect some qualitative differences between people with regard to individual emotions on account of the fact that the mind-brain (not to mention other material systems) differs between persons.

[43]See Lindbeck, *The Nature of Doctrine*, 26. Lindbeck, to his credit, seems to recognize that certain "raw" elements of affective experience are shared between persons of separate religiocultural backgrounds. While I agree with Lindbeck in this instance, I think he downplays the significance of this fact. Moreover, commonality cannot strictly be explained by appeal to culture, religion, or language.

[44]William James, *The Varieties of Religious Experience: A Study in Human Nature*, ed. Matthew Bradley (Oxford: Oxford University Press, 2012), 291. Originally published in 1902.

[45]For example, consider the following: James, *Varieties*, 290ff.; Tracy, *Blessed Rage*, especially 105ff.; Evelyn Underhill, *Mysticism: A Study in Nature and Development of Spiritual Consciousness*, 12th ed. (1930; repr., Santa Cruz, CA: Evinity Publishing, 2009), 413–44; John Hick, *An Interpretation of Religion: Human Responses to the Transcendent*, 2nd ed. (New York: Palgrave Macmillan, 2004), especially 37–41, 187, 292ff.; Robert Sears, "One or Many? How the Psychology of Religion and Emotion Can Help Us Understand Mystical Experience and Critique the Typological Debate within the Theology of Religions" (paper presented at the Center for Missiological Research, Fuller Theological Seminary, Pasadena, CA, 2015).

[46]See the following for discussions of these positions: Lindbeck, *The Nature of Doctrine*, 16–32; Steven T. Katz, "Language, Epistemology, and Mysticism," in *Mysticism and Philosophical Analysis*, ed. Steven T. Katz (London: Sheldon Press, 1978), 22–74.

[47]Andrew B. Newberg, Michael Pourdehnad, Abass Alavi, and Eugene d'Aquili, "Cerebral Blood Flow during Meditative Prayer: Preliminary Findings and Methodological Issues," *Perceptual and Motor Skills* 97 (2003): 625–30; Mario Beauregard and Vincent Paquette, "Neural Correlates of Mystical Experience in Carmelite Nuns," *Neuroscience Letters* 405 (2006): 186–90; David B. Yaden and Andrew B. Newberg, "A New Means for Perennial

Ends: Self-Transcendent Experiences and Noninvasive Brain Stimulation," in *Seeking the Sacred with Psychoactive Substances: Chemical Paths to Spirituality and to God,* vol. 2, ed. J. Harold Ellens (Santa Barbara, CA: Praeger, 2014), 303–24.

[48]Newberg et al., "Cerebral Blood Flow."

[49]W. T. Stace, *Mysticism and Philosophy* (Los Angeles, CA: Jeremy P. Tarcher, 1960).

[50]Ibid., 131–32; cf. Ralph W. Hood Jr., "Construction and Preliminary Validation of a Measure of Reported Mystical Experience," *Journal for the Scientific Study of Religion* 14 (1975): 31–32.

[51]Stace, *Mysticism and Philosophy*, 131.

[52]Ibid., 44–133.

[53]Ibid.

[54]Ibid., 31–38. Stace's work has been vehemently critiqued for relying on experience reports and failing to take into account the diverse meanings different cultures/religions tend to associate with particular words. In accordance with the cultural-linguistic paradigm, Stace's biggest critics assert that mystical experience cannot possibly be the same for people raised in different cultural/religious environs. Although proponents of the cultural-linguistic paradigm are basically correct in this regard, they (again) fail to appreciate the profound cross-cultural similarity between mystical experiences. See Katz, "Language, Epistemology, and Mysticism."

[55]Ralph W. Hood Jr., Nima Ghorbani, P. J. Watson, Ahad Framarz Ghramaleki, Mark N. Bing, H. Kristl Davison, Ronald J. Morris, and W. Paul Williamson, "Dimensions of the Mystical Scale: Confirming the Three-Factor Structure in the United States and Iran," *Journal for the Scientific Study of Religion* 40, no. 4 (2001): 691–705; Aryeh Lazar and Shlomo Kravetz, "Responses to the Mysticism Scale by Religious Jewish Persons: A Comparison of Structural Models of Mystical Experience," *International Journal for the Psychology of Religion* 15, no. 1 (2005): 51–61; Francis-Vincent Anthony, Chris A. M. Hermans, and Carl Sterkens, "A Comparative Study of Mystical Experience among Christian, Muslim, and Hindu Students in Tamil Nadu, India," *Journal for the Scientific Study of Religion* 49, no. 2 (2010): 264–77; Zhuo Chen, Ralph W. Hood Jr., Lijun Yang, and P. J. Watson, "Mystical Experience among Tibetan Buddhists: The Common Core Thesis Revisited," *Journal for the Scientific Study of Religion* 50, no. 2 (2011): 328–38; Zhuo Chen, Wen Qi, Ralph W. Hood Jr., and P. J. Watson, "Common Core Thesis and Qualitative and Quantitative Analysis of Mysticism in Chinese Buddhist Monks and Nuns," *Journal for the Scientific Study of Religion* 50, no. 4 (2011): 654–70; Zhuo Chen, Yang Zhang, Ralph W. Hood Jr., and P. J. Watson, "Mysticism in Chinese Christians and Non-Christians: Measurement Invariance of the Mysticism Scale and Implications for the Mean Differences," *International Journal for the Psychology of Religion* 22, no. 2 (2012): 155–68.

[56]Chen et al., "Qualitative and Quantitative Analysis."

[57]Factor analysis is a statistical procedure that groups survey items/questions into discrete arrangements based on what they seem to share in common. A "factor" is a latent variable that includes each of the items from a single arrangement. For specific factor analyses of the M Scale, consult the works mentioned in endnote 55.

[58]Cf. Jerald D. Gort, Hendrik M. Vroom, Rein Fernhout, and Anton Wessels, eds., *On Sharing Religious Experience: Possibilities of Interfaith Mutuality* (Grand Rapids, MI: Eerdmans, 1992).

[59]See Tsai et al., "Religious Shaping of Feeling," 276–77. Also see Hans-Georg Gadamer, *Truth and Method*, trans. Joel Weinsheimer and Donald G. Marshall, 2nd ed. (New York: Bloomsbury Academic, 2013), especially 311ff. Gadamer speaks of the behavioral application of textual understanding/experience as a work of interpretation. Although understanding (a text/event) cannot be separated from its application according to Gadamer, Tsai and her colleagues suggest that behavior is secondary to affective experience.

[60]Felicitas D. Goodman, *Speaking in Tongues: A Cross-Cultural Study of Glossolalia* (Eugene, OR: Wipf and Stock Publishers, 2008); Pamela A. Moro and James E. Myers, *Magic, Witchcraft, and Religion: A Reader in the Anthropology of Religion*, 8th ed. (New York: McGraw-Hill, 2010).

[61]Quoted in Michelle Voss Roberts, *Tastes of the Divine: Hindu and Christian Theologies of Emotion* (New York: Fordham University Press, 2014), 66.

[62]Quoted in Christopher Wallis, "The Descent of Power: Possession, Mysticism, and Initiation in the Śaiva Theology of Abhinavagupta," *Journal of Indian Philosophy* 36, no. 2 (2008): 265.

[63]Swami Vishnu Tīrtha, *Devatma Shakti: (Kundalini) Divine Power* (Rishikesh: Swami Shivom Tīrth, 1948), 103–105, quoted in Wallis, "The Descent of Power," 292.

[64]Wallis, "The Descent of Power," 293; Margaret M. Poloma, "The 'Toronto Blessing': Charisma, Institutionalization, and Revival," *Journal for the Scientific Study of Religion* 36, no. 2 (1997): 257–71; Margaret M. Poloma and Lynette F. Hoelter, "The 'Toronto Blessing': A Holistic Model of Healing," *Journal for the Scientific Study of Religion* 37, no. 2 (1998): 257–72.

[65]Lindbeck, *The Nature of Doctrine*, 16.

[66]Compare the following: Lindbeck, *The Nature of Doctrine*, 9, 40–41, 115; Paul F. Knitter, *Introducing Theologies of Religions* (Maryknoll, NY: Orbis Books, 2002), 224–32.

[67]Note the fact that experiential-expressivism does not foresee this problem because according to this perspective different religions have the same experience(s) at their core, which, in turn, generate the beliefs/values at issue in dialogue. Since the generative experiences are common between religions, it is assumed that the beliefs/values will be largely common as well. Thus, experiential-expressivists expect different religious persons to find much they can agree about over the course of dialogue.

[68]See Lindbeck, *The Nature of Doctrine*, 114–16.

[69]Placher, *Unapologetic Theology*, 105ff. For Placher, both the extent and types of shared assumptions differ between persons and religious groups. Hence, Christians may have more shared assumptions with Muslims than Hindus, for example, but the types of assumptions shared between Christians and Hindus on the one hand, and Christians and Muslims on the other, are not wholly consistent either. Placher doubts that there is a set of assumptions that *all* persons share equally. While it seems legitimate to claim that both the extent and types of shared assumptions/beliefs vary between persons and religions (perhaps on account of the environments that have historically given shape to various traditions and individuals), there still seem to be some beliefs that, if not held universally, are held by very many and diverse peoples (see the section on "Cognition").

[70]See previous endnote.
[71]I allude to this point in the section on "Cognition" (see my discussion of "God concepts" in particular). For more discussion of this point, see my dissertation "Spiritual Dreams and the Nepalese."
[72]Placher calls this "immanent critique of my own previous assumptions." Placher, *Unapologetic Theology*, 67.
[73]Ibid., 110.
[74]The latter phrase comes from *Nostra Aetate*, the Vatican II document dealing with "the relation of the Church to non-Christian religions."
[75]Cf. Lindbeck, *The Nature of Doctrine*, 38ff.
[76]Francis X. Clooney, *Hindu God, Christian God: How Reason Helps Break Down the Boundaries between Religions* (New York: Oxford University Press, 2001); Francis X. Clooney, *Comparative Theology: Deep Learning across Religious Borders* (Malden, MA: Wiley-Blackwell, 2010); Michelle Voss Roberts, *Tastes of the Divine: Hindu and Christian Theologies of Emotion* (New York: Fordham University Press, 2014).
[77]Kristin Bloomer, "Comparative Theology, Comparative Religion, and Hindu-Christian Studies: Ethnography as Method," *Journal of Hindu-Christian Studies* 21, Article 10 (2008): 33–42.
[78]S. Mark Heim, *Salvations: Truth and Difference in Religion* (Maryknoll, NY: Orbis Books, 1995); ___, *The Depth of the Riches: A Trinitarian Theology of Religious Ends* (Grand Rapids, MI: William B. Eerdmans, 2001); also see Knitter, *Introducing Theologies of Religions*, 173ff. While references to Lindbeck and "cultural-linguistic" theory are not very common in Heim's work, there can be no question that he is quite supportive of both. See, for example, *The Depth of the Riches*, Kindle locations 379–81.
[79]Heim, *The Depth of the Riches*, Kindle locations 496–98.
[80]Although Heim clearly denies the notion of separate essences for each member of the Trinity, his depiction "tends to isolate the persons of the Trinity one from another." Compare the following: McDermott and Netland, *Trinitarian Theology*, p. 82; Heim, *The Depth of the Riches*, chaps. 4 and 5.
[81]For a description of "orthodox" Trinitarianism, see McDermott and Netland, *Trinitarian Theology*, 46–85.
[82]Michael Heiser, "Monotheism, Polytheism, Monolatry, or Henotheism? Toward an Assessment of Divine Plurality in the Hebrew Bible," *Liberty University Faculty Publications and Presentations*, no. 277 (2008), http://digitalcommons.liberty.edu/lts_fac_pubs/277; Michael S. Heiser, *The Unseen Realm: Recovering the Supernatural Worldview of the Bible* (Bellingham, WA: Lexham Press, 2015).
[83]The lack of representation for this view may be due to the relative lack of Pentecostals/charismatics in the theological academy. Pentecostals, in general, seem to be especially receptive to a "diversity of spirits" worldview; hence, one would expect an analogous kind of proposal from a Pentecostal scholar. See Amos Yong, *The Spirit of Creation: Modern Science and Divine Action in the Pentecostal-Charismatic Imagination* (Grand Rapids, MI: William B. Eerdmans, 2011).
[84]For example, see the following: Hick, *Interpretation of Religion*; Knitter, *Introducing Theologies of Religions*; Raimon Panikkar, *The Cosmotheandric Experience: Emerging Religious Consciousness*, ed, Scott T. Eastham (Maryknoll, NY: Orbis Books, 1993); Rahner, *Theological Investigations*; Heim, *The Depth of the Riches*.
[85]Under the divinely inspired scenario, natural/psychological phenomena would continue to have a direct role as instigators of religious experiences. The divine force/entity would be ultimately responsible for the state of affairs that brought the experience to pass, however. See Franks Davis, *The Evidential Force of Religious Experience*, 223–35.
[86]Franks Davis, *The Evidential Force of Religious Experience*.
[87]I am thinking of Lindbeck and Heim in particular. See Lindbeck, *The Nature of Doctrine*; Heim, *The Depth of the Riches*.
[88]See Heim, *The Depth of the Riches*.
[89]In using masculine pronouns for God, I am not attempting to claim that God is male and thus not female or neutral gender. I merely use the male pronoun because of its biblical and historical precedent.

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Philip J. Senter

The Evolution of Creation Science, Part 1: Vestigial Structures and Biological Degeneration

Philip J. Senter and Jared J. Mackey

Creation science (CS) is a discipline in which evidence is sought to support a literal interpretation of the opening chapters of Genesis. Its technical literature has existed since the 1960s, long enough to test for the presence of temporal trends in attitudes toward and stances on specific topics. Here, we present a study of trends over the past fifty years regarding two topics: vestigial structures as understood by mainstream biologists, and biological degeneration as it is understood within the CS paradigm. Perplexingly, through half a century, CS authors have maintained a general consensus that all "created kinds" of organisms have undergone degenerative changes, and they have simultaneously maintained a general consensus that vestigial biological structures do not exist. Because the claim for biological degeneration implies the existence of vestigial structures, CS authors' denial of their existence is incongruous.

According to the young-earth creationist (YEC) worldview, the earth and all kinds of organisms were independently created about 6,000 years ago, as described in the book of Genesis. This worldview is widespread in North America and Europe,[1] despite the teaching of evolution in public schools and despite the biblical injunction against taking Genesis and the rest of the Pentateuch literally.[2] It is unpopular among mainstream scientists, most of whom accept the physical evidence that the earth is billions of years old and that all organisms evolved from a common ancestor.[3] Nevertheless, long before Darwin wrote *On the Origin of Species*, advocates of the YEC school of thought were already challenging the ideas of biological evolution and an old earth.[4]

Such challenges continued through the twentieth century,[5] and in 1961, two of those advocates, John Whitcomb and Henry Morris, produced a best seller, *The Genesis Flood*, which interpreted the geologic record according to the Genesis account of Noah's flood.[6] The arguments in the book are spurious, and point-by-point refutations have been published.[7] However, the book's popularity galvanized a movement that began at about the same time with the establishment of the Creation Research Society[8] (in the founding of which Whitcomb and Morris were involved[9]) and which has come to be called creation science.

Creation science (hereafter abbreviated CS for concision) is a discipline in which extrabiblical support for the Genesis account in its literal sense is sought. CS practitioners publish their studies in peer-reviewed technical journals that accept only manuscripts that concur with a literal interpretation of Genesis. These journals form the core data source for

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today's anti-evolution movement in North America and other English-speaking areas. Information from the technical journals of CS is fed into the anti-evolution movement's popular, nontechnical publications, which make frequent references to studies published in such journals.[10] A list of the technical journals of CS follows below, with the name of each journal followed in parentheses by the abbreviation used for its name in the endnotes.

In 1964 the Creation Research Society launched the earliest such journal, *Creation Research Society Quarterly* (*CRSQ*), which is still issued quarterly today. The first issue of each volume was titled *Creation Research Society Annual* (*CRSA*) until volume 7 in 1970. In 1974 the Geoscience Research Institute, a Seventh-Day Adventist organization, launched the biannual journal *Origins*, which ceased publication after volume 63 in 2008. In 1984, the Creation Science Foundation launched the journal *Ex Nihilo Technical Journal* (*ENTJ*), which was renamed *Creation Ex Nihilo Technical Journal* (*CENTJ*) in 1991, then *TJ* in 2001, and then *Journal of Creation* (*JC*) in 2006, under which name it is currently published. The journal was first published annually. It became biannual in 1991 and triannual in 1996. The Baraminological Study Group launched *Occasional Papers of the Baraminology Study Group* (*OPBSG*) in 2002. Its last issue was published in 2010, whereupon it was succeeded by the *Journal of Creation Theology and Science, Series B: Life Sciences* (*JCTS*), published by the Creation Biology Society. In 2005 the Center for Origins Research launched the occasional journal *CORE Issues in Creation*. In 2008 Answers in Genesis launched the online, open-access journal *Answers Research Journal* (*ARJ*). In addition to these journals, the technical literature of CS continues within the *Proceedings* volumes of the International Conference on Creation series. The conferences are organized by the Creation Science Fellowship in Pittsburgh, Pennsylvania. The first took place in 1986, and the seventh and latest in 2013.

The corpus of CS technical literature has now become large and long-lived enough to test for the presence of temporal trends in positions on specific topics. Here we present a study of such trends in two interrelated topics: the topic of vestigial biological structures as such structures are understood by evolutionary biologists, and the topic of biological degeneration as it is understood by CS authors. Vestigial biological structures, as they are understood by evolutionary biologists, are structures that have become greatly reduced in function and often in size, in comparison to their ancestral homologs.[11] Examples include the eyes of blind cave fishes and blind cave salamanders, the diminutive hindlimbs of pythons, and the miniscule hindlimbs of baleen whales. Most structures that evolutionary biologists recognize as vestigial retain a minor function of some kind, but usually the term "vestigial" is applied only if at least one major ancestral function has been lost[12]—for example, the ability to form an image, in the case of the eyes of blind cave vertebrates. The existence of vestigial structures is often denied in CS technical literature, but in some cases their existence is acknowledged. CS literature addresses the vestigiality not only of morphological structures but also of genes and other molecular entities such as chemical pathways.

The topic of biological degeneration as it is understood by CS authors bears some resemblance to mainstream science's concept of vestigialization, but there are important differences. Biological degeneration as it is understood by CS authors includes heritable change involving compromised function, morphological reduction, or genome reduction, whether or not it involves a discrete structure that mainstream scientists would recognize as a vestige. According to the YEC paradigm, biological degeneration is not due to natural selection but is a result of the Fall of humankind, that is, Adam and Eve's sin, which introduced the Curse of decay into the created world.[13] Implicit in the YEC concept of biological degeneration is the premise that due to the decay caused by sin, heritable change can be only neutral or degenerative. This means that any heritable change that appears to be advantageous in some way is disadvantageous in some other way(s) that outweighs the advantage, or that any apparent advantage in phenotype is an incidental result of degeneration of the genotype. For example, two CS authors claim that "mutations [that confer antibiotic resistance and other benefits in microbes] frequently eliminate or reduce pre-existing cellular systems and functions."[14]

Within the topic of biological degeneration are several subtopics that are frequently addressed in CS technical literature: (1) biological degeneration as an explanation for the morphology of extinct species of *Homo* (e.g., *H. neanderthalensis* and *H. erectus*), (2) reduction in the human lifespan after the Flood as an example of biological degeneration, (3) pathogenicity or parasitism as the result of biological

degeneration, (4) apparently beneficial mutations as examples of biological degeneration, and (5) use of the term "devolution" in reference to heritable changes that are degenerative.

Materials and Methods

We sought to determine whether temporal trends in CS technical literature exist in the topics and subtopics identified in the previous three paragraphs. To limit the analysis strictly to technical literature, we examined only technical articles and conference abstracts from the journals mentioned above. We ignored editorials, letters to the editor, article reviews, book reviews, and such. As for conference abstracts, we examined only those that were published in *OPBSG* and *ARJ*, for two reasons: (1) abstracts published in other CS journals tend to be published afterwards as full-length articles (which would introduce redundancy if they were considered here), whereas those in *OPBSG* and *ARJ* do not, and (2) *OPBSG* and *ARJ* abstracts function as short articles, because they include references and are longer than abstracts usually are.

Most issues of most CS journals have been converted to PDF files, which can be purchased or are posted online for free access. To search these files for articles that addressed the topic of vestigial biological structures we used the search term "vestig" (to find the terms "vestigial," "vestige," and "vestiges") and "rudiment" (to find the terms "rudiment," "rudiments," and "rudimentary"). To search the PDFs for articles that addressed the topic of biological degeneration within the YEC paradigm we used the search terms "degenera" (to find the words "degenerate," "degeneration," etc.), "deteriorat" (to find the words "deteriorate," "deterioration," etc.), "devol" (to find the words "devolve," "devolution," etc.), "de-vol" (to find the words "de-volve," "de-volution," etc.), "de-evol" (to find the words "de-evolve," "de-evolution," etc.), and "decay." PDF files are unavailable for volumes 1, 2, and 4 of *ENTJ*; volumes 5–8 of *CENTJ*; and all volumes of *CORE Issues in Creation*. For those volumes, we searched visually through paper copies.

We 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. We then compared attitudes toward and interest in the chosen topics and subtopics through time, as revealed in the number of authors advocating a given view or addressing a given topic in the CS technical articles of each period. For each period, we also counted the overall number of CS authors and the number of new CS authors (any author whose earliest CS technical article was published during that period), to determine whether any apparent increase in interest in a given topic or subtopic is an artifact of an increase in the overall number of CS authors or of an increase in the number of new CS authors.

For two of the CS technical journals (*CRSQ* and *JC*), the societies that publish the journals mail printed copies to institutional subscribers and to individual members of the societies. We contacted the editorial offices of those two journals and requested the number of individual and institutional subscribers. This was to determine whether the circulation of CS technical journals reaches much (if any) further than the circle of CS authors.

Results

The overall number of CS authors increased from 50 in 1964–1970 to 213 in 2011–2015 (table 1; fig. 1). Sharp rises in the number of new CS authors occurred in 1976–1980 and in 2001–2005, whereas the number of continuing CS authors rose steadily through the decades with no sharp increases (fig. 1).

As of June 13, 2016, *CRSQ* is sent to 165 institutional subscribers (libraries and others) and 1,045 members of the Creation Research Society. Given that there were only 213 CS authors in 2011–2015, it is evident that the circulation of CS technical literature reaches considerably further than the circle of CS authors. The editorial office of *JC* declined to provide subscription numbers.

Table 1. Number of authors publishing articles in the technical journals of creation science through 2015.

	1964–1970	1971–1975	1976–1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2010	2011–2015
Total number of authors	50	81	150	124	173	174	174	212	221	213
New authors	50	34	101	69	101	103	94	129	121	118
Continuing authors		47	49	55	72	71	80	83	100	95

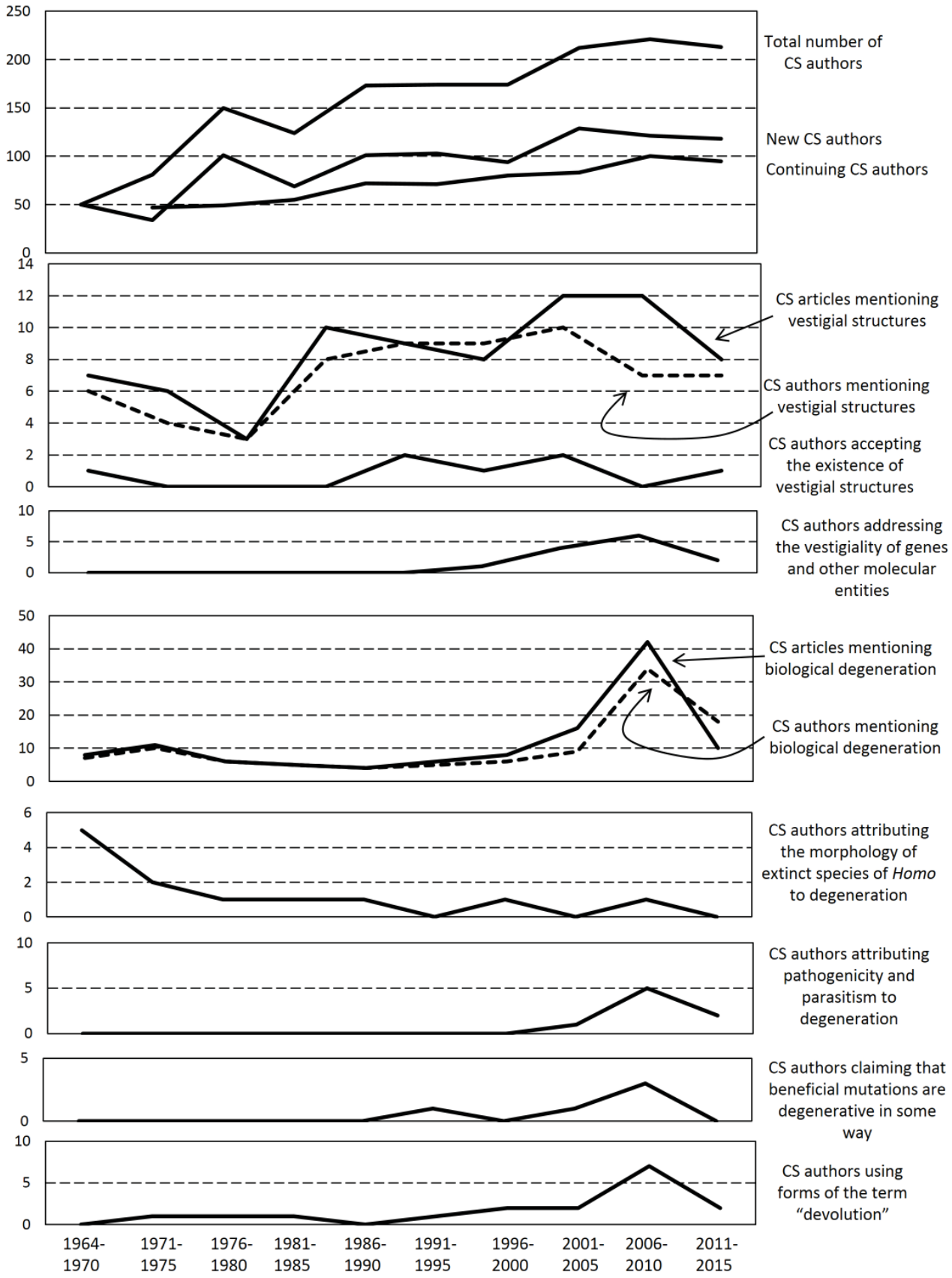

Figure 1. Temporal trends in the technical literature of creation science through 2015: number of authors, and acceptance of and interest in topics relating to vestigial biological structures and biological degeneration.

We found 81 articles that address the evolutionary topic of vestigial biological structures. In most of these, the authors express the opinion that such structures do not exist, but a few authors acknowledge the existence of such structures (table 2; fig. 1). The number of authors that acknowledge the existence of such structures is small (0–2) in all time periods, and there is no overall increase or decrease in the acceptance of the existence of vestigial biological structures by CS authors over time. All authors addressing the topic of vestigial structures addressed only morphology, until the early 1990s, after which a few authors in each period addressed the vestigiality of genes or other molecular entities (table 2; fig. 1).

Table 2. References to vestigial biological structures in the technical literature of creation science through 2015. In the Stance column, "for" indicates acceptance of vestigiality, and "against" indicates rejection of vestigiality.

Author and year	Stance	Biological structure(s) in question
Morris 1964[1]	for	general
Rusch 1966[2]	against	human tonsils, parathyroid glands, thymus, pineal gland, appendix, coccyx, plica semilunaris; snake spurs; mysticete whale teeth
Klotz 1966[3]	for	mutant fruit flies
Howitt 1968[4]	against	coccyx
Marsh 1969[5]	?	sterile pollen of dandelion; blind cavefish eyes
Artist 1969[6]	against	human appendix; python hindlimbs; whale hindlimbs; kiwi wings
Shute 1970[7]	?	hyrax outer toes
Ouweneel 1971[8]	against	general
Turner 1972[9]	against	general
Howitt 1972[10]	against	general
Armstrong 1972[11]	against	pineal gland
Armstrong 1972[12]	against	tonsils
Ouweneel 1975[13]	?	wings of the fly *Termitoxenia*
Woodmorappe 1978[14]	against	septa in cephalopod shells
Smith 1979[15]	against	snake hindlimbs
Licata 1979[16]	against	general
Hedtke 1981[17]	against	general
Howe 1982[18]	against	general
Bergman 1982[19]	against	general
Jones 1982[20]	against	ape and human pinna
Hinderliter 1982[21]	against	general
Meyer 1982[22]	against	general
Hedtke 1983[23]	against	general
Smith 1985[24]	against	caecilian eyes
Meyer 1985[25]	against	general
Smith 1985[26]	against	human appendix, tonsils, thymus, pineal gland
Sanders and Howe 1986[27]	?	mouthparts of non-eating insects
Hamilton 1987[28]	?	eyes of snake ancestor
Hamilton 1987[29]	for	caecilian eyes
Bird 1988[30]	against	general
Glover 1988[31]	against	human appendix
Leslie 1988[32]	against	human appendix, tonsils, fetal yolk sac
Cooper 1988[33]	against	sagittal keel of late *Homo*
Snelling 1989[34]	against	human appendix
Woodmorappe 1990[35]	for	fly wings
Bergman 1992[36]	against	general
Lumsden, Anders, and Pettera 1992[37]	against	nontranscribing and nontranslating DNA
Kaplan 1993[38]	against	human ear muscles
Bergman 1994[39]	against	wisdom teeth
Maas 1994[40]	against	human appendix
Gibson 1994[41]	against	general
Wise 1995[42]	for	whale hindlimbs
Colwell 1996[43]	against	human appendix
Wise 1996[44]	for	goose wings
Wieland 1997[45]	against	"junk genes"
Sarfati 1997[46]	against	thymus
Batten 1998[47]	against	introns
Wieland 1998[48]	against	fly halters
Bergman 1998[49]	against	wisdom teeth
Hedtke 1999[50]	against	general
Bergman 2000[51]	against	mammalian yolk sac
Jerlström 2000[52]	for	wallaby chromosome retroelements
Walkup 2000[53]	against	introns
Menton 2000[54]	against	human plantaris muscle
Bergman 2000[55]	against	human appendix, tonsils, pineal gland, thymus
Bergman 2001[56]	against	general; transposons
Bergman 2001[57]	against	general
Bergman 2001[58]	against	human male nipple
Gurney 2001[59]	against	plica semilunaris
Wood and Cavanaugh 2001[60]	against	general; "junk DNA"
Bergman 2002[61]	against	eye-related glands
Standish 2002[62]	against	noncoding DNA
Bell 2004[63]	against	cytochrome c
Bergman 2004[64]	against	general
Woodmorappe 2004[65]	against	GULO pseudogene
Batten 2005[66]	against	general
Armitage and Howe 2007[67]	against	fungal ascospores and ascocarps; sucrose metabolism
Bergman 2008[68]	against	prostate accessory structures
Doyle 2008[69]	against	human vomeronasal organ, goose bumps, Darwin's point, coccyx, wisdom teeth
Hendriksen 2008[70]	against	general
Bergman 2009[71]	against	snake spurs
Carter 2009[72]	against	retrotransposons
Wise 2009[73]	for	whale limbs and pelves
Bergman 2010[74]	against	general
Bergman 2011[75]	against	general
Niekirk 2011[76]	against	placental mammal yolk sac
Bergman 2012[77]	against	whale hindlimbs, fetal tooth buds, hairlets
Bergman 2013[78]	against	pseudogenes
McDonald 2013[79]	?	kiwi wings
Hennigan 2014[80]	against	snake spurs
Aaron 2014[81]	for	tyrannosaurid arms

[1]Henry M. Morris, "The Power of Energy," *Creation Research Society Annual* (hereafter *CRSA*) 1 (1964): 18–23.
[2]Wilbert Rusch, "Analysis of So-called Evidences of Evolution," *CRSA* 3 (1966): 4–15.
[3]John W. Klotz, "The Philosophy of Science in Relation to Concepts of Creation vs. the Evolution Theory," *Creation Research Society Quarterly* (hereafter *CRSQ*) 3 (1966): 3–11.
[4]John R. Howitt, "Man, the Upright," *CRSA* 5 (1968): 46–48.
[5]Frank L. Marsh, "The Form and Structure of Living Things," *CRSA* 6 (1969): 13–25.
[6]Russell Artist, "The Concept of Homology," *CRSA* 6 (1969): 55–64, 66.
[7]Evan V. Shute, "Puzzling Similarities," *CRSQ* 7, no. 3 (1970): 147–51.
[8]Willem J. Ouweneel, "The Scientific Character of the Evolution Doctrine," *CRSQ* 8, no. 2 (1971): 109–115.
[9]C. E. A. Turner, "Teleology: Purpose Everywhere," *CRSQ* 9, no. 1 (1972): 38–40.
[10]John R. Howitt, "Some Observations on the Science of Nutrition in the Light of the Scriptures," *CRSQ* 9, no. 1 (1972): 51–53.
[11]Harold Armstrong, "Comments on Scientific News and Views," *CRSQ* 9, no. 2 (1972): 131–39.
[12]___, "Comments on Scientific News and Views," *CRSQ* 9, no. 3 (1972): 181–83.
[13]Willem J. Ouweneel, "Homoeotic Mutants and Evolution," *CRSQ* 12, no. 3 (1975): 141–54.
[14]John Woodmorappe, "The Cephalopods in the Creation and the Universal Deluge," *CRSQ* 15, no. 2 (1978): 94–112.
[15]E. Norbert Smith, "Another Vestigial Structure Found Useful," *CRSQ* 15, no. 4 (1979): 215.
[16]David P. Licata, "A Unit on Biological Origins for the Secular Classroom," *CRSQ* 16, no. 1 (1979): 60–63.
[17]Randall Hedtke, "The Episteme Is the Theory," *CRSQ* 18, no. 1 (1981): 8–13, 26.
[18]George F. Howe, "Postfire Strategies of Two Chaparral Shrubs (Chamise and Ceanothus) Cast Light on Origins," *CRSQ* 19, no. 1 (1982): 3–10.
[19]Jerry Bergman, "Reality: Real or Conventional?," *CRSQ* 19, no.1 (1982): 67–68, 35, 39.
[20]A. J. Jones, "A Creationist Critique of Homology," *CRSQ* 19, no. 3 (1982): 156.
[21]Hilton Hinderliter, "Professor Frick—and the Theory in Stone," *CRSQ* 19, no. 3 (1982): 175–78.
[22]John R. Meyer, "Vestigial Organs (If They Exist at All) Prove Nothing," *CRSQ* 19 (1982): 190–91.
[23]Randall Hedtke, "The Principle of Applied Creation in an Origin Curriculum," *CRSQ* 20 (1983): 44–46.
[24]E. Norbert Smith, "To See or Not to See," *CRSQ* 21, no. 4 (1985): 198.
[25]John R. Meyer, "Origin of the Kaibab Squirrel," *CRSQ* 22, no. 2 (1985): 68–77.
[26]E. Norbert Smith, "The Role of Creation Research in Modern Biology," *CRSQ* 22, no. 3 (1985): 105–7.
[27]Robert R. Sanders and George F. Howe, "Insects Indicate Creation," *CRSQ* 22, no. 4 (1986): 166–70.
[28]H. S. Hamilton, "The Snake's Spectacular Spectacle," *CRSQ* 23, no. 4 (1987): 177–78.
[29]___, "Convergent Evolution—Do the Octopus and Human Eyes Qualify?," *CRSQ* 24, no. 2 (1987): 82–85.
[30]W. R. Bird, "The Postulated Evidence for Macroevolution and Darwinism: Darwinian Arguments and the Disintegrating Neo-Darwinian Synthesis—Part II," *CRSQ* 25, no. 2 (1988): 74–81.
[31]J. Warwick Glover, "The Human Vermiform Appendix—A General Surgeon's Reflections," *Ex Nihilo Technical Journal* (hereafter *ENTJ*) 3 (1988): 31–38.
[32]J. G. Leslie, "The Hindrance of Evolutionary Terminology to the Teaching of Science," *Creation ex nihilo Technical Journal* (hereafter *CENTJ*) 3, no. 1 (1988): 59–64.
[33]Bill Cooper, "Rhodesian Man," *ENTJ* 3 (1988): 137–51.
[34]Andrew Snelling, "Australian Publications," *CRSQ* 26, no. 1 (1989): 33–34.
[35]John Woodmorappe, "Causes for the Biogeographic Distribution of Land Vertebrates after the Flood," in *Proceedings of the Second International Conference on Creationism,* ed. Robert E. Walsh (Pittsburgh, PA: Creation Science Fellowship, 1990), 53–66.
[36]Jerry Bergman, "Some Biological Problems with the Natural Selection Theory," *CRSQ* 29, no. 3 (1992): 146–58.
[37]Richard D. Lumsden, Paul C. Anders, and Jeffery R. Pettera, "Genetic Information and McCann's Dual Factor Paradigm for Development and Variation," *CRSQ* 29, no. 2 (1992): 63–69.
[38]John Kaplan, "Functional External Ear Muscles," *CRSQ* 30 (1993): 90.
[39]Jerry Bergman, "The Wisdom of Saving Wisdom Teeth," *CRSQ* 31, no. 2 (1994): 74–77.
[40]Frank Maas, "Immune Functions of the Vermiform Appendix," in *Proceedings of the Third International Conference on Creationism,* ed. Robert E. Walsh (Pittsburgh, PA: Creation Science Fellowship, 1994), 335–42.
[41]L. James Gibson, "Pseudogenes and Origins," *Origins* 21 (1994): 21–108.
[42]Kurt P. Wise, "Towards a Creationist Understanding of Transitional Forms," *CENTJ* 9, no. 2 (1995): 216–22.
[43]Gary Colwell, "Socrates Meets Darwin: A Study in Question Begging," *CRSQ* 33, no. 2 (1996): 127–35.
[44]Kurt P. Wise, "North American Paleontology Convention 96," *CENTJ* 10, no. 3 (1996): 315–21.
[45]C. Wieland, "'Junk'-making Viruses Neutralise an Evolutionary Argument," *CENTJ* 10, no. 3 (1996): 296–97.
[46]Jonathan D. Sarfati, "Blood Types and Their Origin," *CENTJ* 11, no. 1 (1997): 31–32.
[47]D. J. Batten, "'Junk' DNA (Again)," *CENTJ* 12, no. 1 (1998): 5.
[48]Carl Wieland, "Why a Fly Can Fly like a Fly," *CENTJ* 12, no. 3 (1998): 260–61.
[49]Jerry Bergman, "Are Wisdom Teeth (Third Molars) Vestiges of Human Evolution?," *CENTJ* 12, no. 3 (1998): 297–304.
[50]Randall Hedtke, "How Gradual Evolution Is Disproved in the Textbooks," *CRSQ* 36, no. 3 (1999): 136–44.
[51]Jerry Bergman, "The Rise and Fall of Haeckel's Biogenetic Law," *CRSQ* 37, no. 2 (2000): 110–22.
[52]Pierre Jerlström, "Jumping Wallaby Genes and Post-Flood Speciation," *CENTJ* 14, no. 1 (2000): 9–10.
[53]Linda K. Walkup, "Junk DNA: Evolutionary Discards or God's Tools?," *CENTJ* 14, no. 2 (2000): 18–30.
[54]David N. Menton, "The Plantaris and the Question of Vestigial Muscles in Man," *CENTJ* 14, no. 2 (2000): 50–53.
[55]Jerry Bergman, "Do Any Vestigial Organs Exist in Humans?," *CENTJ* 14, no. 2 (2000): 95–98.
[56]___, "The Molecular Biology of Genetic Transposition," *CRSQ* 38 (2001): 139–50.
[57]___, "Does Homology Provide Evidence of Evolutionary Naturalism?," *Technical Journal* (hereafter *TJ*) 15, no. 1 (2001): 26–33.
[58]___, "Is the Human Male Nipple Vestigial?," *TJ* 15, no. 2 (2001): 38–41.
[59]Peter Gurney, "Dawkins' Eye Revisited," *TJ* 15, no. 3 (2001): 92–99.
[60]Todd C. Wood and David P. Cavanaugh, "A Baraminological Analysis of Subtrive Flaveriinae (Asteraceae: Helenieae) and the Origin of Biological Complexity," *Origins* 52 (2001): 7–27.
[61]Jerry Bergman, "The Design of Tears: An Example of Irreducible Complexity," *TJ* 16, no. 1 (2002): 86–89.
[62]Timothy G. Standish, "Rushing to Judgment: Functionality in Non-coding or 'Junk' DNA," *Origins* 53 (2002): 7–30.
[63]Philip B. Bell, "The Non-evolution of Apoptosis," *TJ* 18, no. 1 (2004): 86–96.
[64]Jerry Bergman, "Human Embryonic Gills and Gill Slits—Down but Not Out," *TJ* 18, no. 1 (2004): 71–75.
[65]John Woodmorappe, "Potentially Decisive Evidence against Pseudogene 'Shared Mistakes,'" *TJ* 18, no. 3 (2004): 63–69.
[66]Don Batten, "No Joy for Junkies," *TJ* 19, no. 1 (2005): 3.
[67]Mark H. Armitage and George F. Howe, "The Ultrastructure of Lichen Cells Supports Creation, Not Macroevolution: A Photo Essay and Literature Review—Part II," *CRSQ* 44, no. 2 (2007): 107–18.
[68]Jerry Bergman, "Was the Prostate Gland Poorly Designed?," *CRSQ* 44, no. 3 (2008): 230–35.
[69]Shaun Doyle, "Vestigial Arguments: Remnants of Evolution," *Journal of Creation* (hereafter *JC*) 22, no. 2 (2008): 40–42.
[70]Janet Henriksen, "The Design Paradigm," *JC* 22, no. 2 (2008): 53–59.
[71]Jerry Bergman, "Evidence for the Lack of Snake Evolution," *CRSQ* 45, no. 4 (2009): 258–70.
[72]Kurt P. Wise, "Mammal Kinds: How Many Were on the Ark?," *CORE Issues in Creation* 5 (2009): 129–61.
[73]Robert W. Carter, "The Slow, Painful Death of Junk DNA," *JC* 23, no. 3 (2009): 12–13.

[74]Jerry Bergman, "*Inherit the Wind*: A Lesson in Distorting History," *Answers Research Journal* (hereafter *ARJ*) 3 (2010): 61–69.
[75]___, "C. Everett Koop—Christian and Darwin Doubter," *JC* 25, no. 3 (2011): 63–67.
[76]E. van Niekirk, "Countering Revisionism—Part 1: Ernst Haeckel, Fraud Is Proven," *JC* 25, no. 3 (2011): 89–95.
[77]Jerry Bergman, "Whale Evolution: A Whale of a Tale," *CRSQ* 49, no. 2 (2012): 122–34.
[78]___, "The Origins and Genetic Functions of Pseudogenes," *CRSQ* 49, no. 4 (2013): 308–18.
[79]Christine McDonald, "The Kiwi," *JC* 27, no. 1 (2013): 68–70.
[80]Tom Hennigan, "An Initial Estimate toward Identifying and Numbering Extant Tuatara, Amphisbaena, and Snake Kinds," *ARJ* 7 (2014): 31–47.
[81]M. Aaron, "Discerning Tyrants from Usurpers: A Statistical Baraminological Analysis of Tyrannosauroidea Yielding the First Dinosaur Holobaramin," *ARJ* 7 (2014): 463–81.

We found 125 articles that address the topic of biological degeneration within the YEC paradigm (table 3; fig. 1). The number of such articles and the number of authors writing on the topic peaked sharply in the second half of the first decade of the twenty-first century. Because there was no simultaneous spike in the number of new CS authors or in the total number of CS authors (fig. 1), this sharp rise cannot be explained by an increase in the number of CS authors.

The number of CS authors attributing the morphology of extinct species of *Homo* to degeneration was initially high but decreased over time and has remained at zero through the present century (fig. 1). The number of CS authors citing post-Flood reduction in the human lifespan as an example of biological degeneration has always been low: one such citation apiece in 1978, 1998, 2000, and 2009, and two in 1998 (table 3). The number of CS authors attributing pathogenicity or parasitism to degeneration peaked during the period at which the number of CS authors addressing biological degeneration was highest (2006–2010). The number of CS authors claiming that apparently beneficial mutations represent genetic degeneration peaked during the same period. These two spikes may therefore be connected with the increase in the number of CS authors publishing on the topic of biological degeneration during that period. The number of CS authors using forms of the term "devolution" peaked during the same period.

Table 3. References to biological degeneration in the technical literature of creation science through 2015. *Homo* = attribution of morphology of extinct species of *Homo* to degeneration; lifespan = assertion that post-Flood reduction in human lifespans represents degeneration; P&P = attribution of parasitism and pathogenicity to degeneration; BMD = claim that beneficial mutations are degenerative; dev = use of some form of the term "devolution."

Author and year	*Homo*	lifespan	P&P	BMD	dev
Lammerts 1964[1]					
Tinkle 1964[2]	X				
Morris 1965[3]					
Rusch 1966[4]					
Custance 1968[5]	X				
Cook 1968[6]	X				
Tinkle 1968[7]					
Shaw 1970[8]	X				
Lockwood 1971[9]					
Ouweneel 1971[10]	X				
Morris 1971[11]					
Moore 1972[12]					
Williams 1973[13]					
Telfair 1973[14]					
Siegler 1974[15]					X
Clark 1974[16]	X				
Wheeler 1975[17]					
Quinn 1975[18]					
Ouweneel 1975[19]					
Moore 1976[20]	X				
Sharp 1977[21]					
Strickling 1978[22]		X			
Sigler 1978[23]					
Licata 1979[24]					
Ancil 1980[25]					
Guenter 1981[26]	X				
Moore 1982[27]					
Jones 1982[28]					X
Brown 1983[29]					
McCluskey 1985[30]					
Leslie 1986[31]					
Gentry 1986[32]					
Marsh 1987[33]					
Bowden 1988[34]	X				
Wieland 1991[35]				X	
Bergman, J. 1992[36]					X
Brand and Gibson 1993[37]					
Wieland 1994[38]		X			
Beasley 1995[39]					
Bergman, J. 1995[40]					X
Wieland 1996[41]					
García-Pozuelo-Ramos 1997[42]	X				
Bergman, J. 1998[43]		X			X
Bergman, D. 1998[44]					X
Cuozzo 1998[45]		X			X
Walkup 2000[46]					
Armitage and Lumsden 2000[47]					
Bergman, J. 2000[48]		X			
Mastropaolo 2001[49]					X
Wood 2001[50]					
Batten 2001[51]			X		
Bergman, J. 2001[52]					
Bergman, J. 2001[53]					
Bergman, J. 2002[54]					X
Standish 2002[55]					
Bell 2002[56]					
Batten 2002[57]					
Sanders and Wise 2003[58]					
Wood 2003[59]					

Author and year	*Homo*	lifespan	P&P	BMD	dev
Batten 2003[60]				X	
Murdock 2004[61]					X
Murdock 2004[62]					
Wood 2005[63]					
Bergman, J. 2005[64]					
Gillen & Sherwin 2006[65]			X		X
Lamb 2006[66]			X	X	
Murdock 2006[67]					X
Liu and Moran 2006[68]					
Lucas and Wood 2006[69]					
Bergman, J. 2007[70]					X
Kim 2007[71]					
Williams 2007[72]					
Wood 2007[73]					
Baldwin 2007[74]					
Wood 2007[75]					
Gillen and Hubbard 2007[76]					
Gillen 2008[77]					
Loucks 2008[78]			X		X
Gillen 2008[79]					
Lightner 2008[80]					
Lightner 2008[81]					
Kim 2008[82]					
Bergman 2008[83]					
Sanford et al. 2008[84]					
Anderson and Purdom 2008[85]				X	
Baumgardner et al. 2008[86]					
Bergman, J. 2008[87]					
Carter et al. 2008[88]					
Doyle 2008[89]					
Williams 2008[90]					
Williams 2008[91]					
Brand 2008[92]				X	

Author and year	*Homo*	lifespan	P&P	BMD	dev
Hennigan 2008[93]					
Liu and Snooper 2009[94]					
Sherwin 2009[95]			X		
Loucks 2009[96]					X
Purdom 2009[97]			X		
Liu 2009[98]					
Bergman 2009[99]					
Larssen 2009[100]		X			
Borger 2009[101]					
Habermehl 2010[102]					X
Lightner 2010[103]					
Sarfati 2010[104]					X
Thomas 2010[105]					
Doyle 2010[106]					
Doyle 2011[107]					
Carter 2011[108]					
Doyle 2011[109]					
Tomkins 2013[110]					
Bergman, J. 2013[111]					
Rupe and Sanford 2013[112]					
Arneigh 2013[113]					X
O'Micks 2013[114]					X
Terborg 2013[115]					
Tomkins 2014[116]					
Williams 2014[117]					
Robinson 2014[118]					
Blaschke 2014[119]			X		
Liu 2015[120]					X
Liu 2015[121]					
Liu 2015[122]					
Gillen et al. 2015[123]			X		
Tan 2015[124]					
Murphy 2015[125]					

[1]Walter E. Lammerts, "Discoveries Since 1859 Which Invalidate the Evolution Theory," *Creation Research Society Annual* (hereafter *CRSA*) 1 (1964): 47–55.
[2]William J. Tinkle, "Evolution: The Paradox of a Century," *Creation Research Society Quarterly* (hereafter *CRSQ*) 1 (1964): 8–9.
[3]Henry M. Morris, "Science versus Scientism in Historical Geology," *CRSA* 2 (1965): 19–28.
[4]Wilbert Rusch, "Analysis of So-called Evidences of Evolution," *CRSA* 3 (1966): 4–15.
[5]Arthur C. Custance, "Fossil Man in Light of the Record in Genesis," *CRSA* 5 (1968): 5–22.
[6]Melvin A. Cook, "Radiological Dating and Some Pertinent Applications of Historical Interest: Do Radiological 'Clocks' Need Repair?," *CRSQ* 5 (1968): 69–77.
[7]William J. Tinkle, "The Ancestry of Man," *CRSA* 5 (1968): 42–45.
[8]R. Daniel Shaw, "Fossil Man: Ancestor or Descendant of Adam?," *CRSQ* 6, no. 4 (1970): 172–81.
[9]G. C. Lockwood, "The Second Law of Thermodynamics and Evolution," *CRSQ* 8 (1971): 8, 23.
[10]Willem J. Ouweneel, "The Scientific Character of the Evolution Doctrine," *CRSQ* 8, no. 2 (1971): 109–115.
[11]Henry M. Morris, "Proposal for Science Framework Guidelines," *CRSQ* 8 (1971): 147–50.
[12]John N. Moore, "On Chromosomes, Mutations, and Phylogeny," *CRSQ* 9 (1972): 159–71.
[13]Emmett L. Williams, "Thermodynamics: A Tool for Creationists," *CRSQ* 10, no. 1 (1973): 38–44.
[14]Raymond C. Telfair II, "Should Evolution Be Taught as Fact?," *CRSQ* 10, no. 1 (1973): 53–61.
[15]Hilbert R. Siegler, "The Magnificence of Kinds as Demonstrated by Canids," *CRSQ* 11, no. 2 (1974): 94–97.
[16]Harold W. Clark, "Fossil Man and the Creation Concept," *CRSQ* 11, no. 2 (1974): 115–20.
[17]Gerald Wheeler, "The Cruelty of Nature," *Origins* 2 (1975): 32–41.
[18]Lloyd Y. Quinn, "Evidence for the Existence of an Intelligible Genetic Code," *CRSQ* 11, no. 4 (1975): 188–98.
[19]Willem J. Ouweneel, "Homoeotic Mutants and Evolution," *CRSQ* 12, no. 3 (1975): 141–54.
[20]John N. Moore, "On Methods of Teaching Origins: A Progress Report," *CRSQ* 13, no. 1 (1976): 46–55.
[21]Douglas B. Sharp, "Interdependence in Macromolecule Synthesis: Evidence for Design," *CRSQ* 14, no. 1 (1977): 54–61.
[22]James E. Strickling, "Creation, Evolution and Catastrophism," *CRSQ* 15, no. 1 (1978): 12–14.
[23]Hilbert R. Siegler, "A Creationist's Taxonomy," *CRSQ* 15, no. 1 (1978): 36–38, 11.
[24]David P. Licata, "A Unit on Biological Origins for the Secular Classroom," *CRSQ* 16, no.1 (1979): 60–63.
[25]Ralph E. Ancil, "A Proposal for a New Creationist Discipline," *CRSQ* 17, no. 2 (1980): 123–27.
[26]Ken Guenter, "Implications of Palaeolithic Stratigraphy for Creationist Models of Prehistory," *CRSQ* 18, no. 3 (1981): 168–70.
[27]John N. Moore, "An Estimate of the Current Status of Evolutionary Thinking," *CRSQ* 18, no. 4 (1982): 189–97.
[28]A. J. Jones, "A Creationist Critique of Homology," *CRSQ* 19, no. 3 (1982): 156.
[29]Colin Brown, "The Pentadactyl Plan," *CRSQ* 20, no. 1 (1983): 3–7.
[30]Elwood S. McCluskey, "Which Vertebrates Can Make Vitamin C?," *Origins* 12 (1985): 96–100.
[31]John Leslie, "Mutations and Design in Cellular Metabolism," *Ex Nihilo Technical Journal* (hereafter *ENTJ*) 2 (1986): 17–52.
[32]Robert Gentry, "Radioactive Halos: Implications for Creation," in *Proceedings of the First International Conference on Creationism,* ed. Robert E. Walsh (Pittsburgh, PA: Creation Science Fellowship, 1986), 89–112.
[33]Frank L. Marsh, "Five-Linked Food Chain of Insects," *CRSQ* 23, no. 4 (1987): 145–51.

[34]Malcolm Bowden, "*Homo erectus*—A Fabricated Class of 'Ape-Men,'" *ENTJ* 3 (1988): 152–53.
[35]Carl Wieland, "Variation, Information and the Created Kind," *Creation ex nihilo Technical Journal* (hereafter *CENTJ*) 5, no. 1 (1991): 42–47.
[36]Jerry Bergman, "Some Biological Problems with the Natural Selection Theory," *CRSQ* 29, no. 3 (1992): 146–58.
[37]Leonard R. Brand and L. James Gibson, "An Interventionist Theory of Natural Selection and Biological Change within Limits," *Origins* 20 (1993): 60–82.
[38]Carl Wieland, "Decreased Lifespans: Have We Been Looking in the Right Place?," *CENTJ* 8, no. 2 (1994): 138–41.
[39]Greg J. Beasley, "Archaic Fossil Human Remains—An Update," *CENTJ* 9, no. 2 (1995): 169–215.
[40]Jerry Bergman, "Mutations and Evolution," *CENTJ* 9, no. 2 (1995): 146–54.
[41]C. Wieland, "Lost World of Mutants Discovered," *CENTJ* 10, no. 2 (1996): 172–73.
[42]Celedonio García-Pozuelo-Ramos, "Taxonomy of Primates," *CRSQ* 34, no. 2 (1997): 93–114.
[43]Jerry Bergman, "The Transitional Form Problem," *CRSQ* 35, no. 3 (1998): 134–47.
[44]David L. Bergman, "Conflict of Atomism and Creationism in History," in *Proceedings of the Fourth International Conference on Creationism,* ed. Robert E. Walsh (Pittsburgh, PA: Creation Science Fellowship, 1998), 53–66.
[45]John W. Cuozzo, "What Happens to the Craniofacial Structure of Humans Who Live Past 100 Years? Neanderthal Similarities," in *Proceedings of the Fourth International Conference on Creationism,* ed. Walsh, 103–20.
[46]Linda K. Walkup, "Junk DNA: Evolutionary Discards or God's Tools?," *CENTJ* 14, no. 2 (2000): 18–30.
[47]Mark H. Armitage and Richard D. Lumsden, "Parasitism by Design? The Surface Micromorphology of Flatworms," *CRSQ* 37 (2000): 105–8.
[48]Jerry Bergman, "The Life Clock and Paley's Watch: The Telomeres," *CRSQ* 37, no. 3 (2000): 176–83.
[49]Joseph Mastopaolo, "Evolution Is Lethal Antiscience," *CRSQ* 38 (2001): 151–58.
[50]Todd C. Wood and David P. Cavanaugh, "A Baraminological Analysis of Subtrive Flaveriinae (Asteraceae: Helenieae) and the Origin of Biological Complexity," *Origins* 52 (2001): 7–27.
[51]Don Batten, "Food Scare Leads to Design Discovery," *Technical Journal* (hereafter *TJ*) 15, no. 1 (2001): 13–14.
[52]Jerry Bergman, "Does Homology Provide Evidence of Evolutionary Naturalism?," *TJ* 15, no. 1 (2001): 26–33.
[53]___, "Evolutionary Naturalism: An Ancient Idea," *TJ* 15, no. 2 (2001): 77–80.
[54]___, "Why Mutations Are Lethal to Darwinism," *CRSQ* 38, no. 4 (2002): 181–89.
[55]Timothy G. Standish, "Rushing to Judgment: Functionality in Noncoding or 'Junk' DNA," *Origins* 53 (2002): 7–30.
[56]Philip Bell, "Apoptosis: Cell Death Reveals Creation," *TJ* 16, no. 1 (2002): 90–102.
[57]Don Batten, "More Junk Reclaimed," *TJ* 16, no. 2 (2002): 8.
[58]Roger W. Sanders and Kurt P. Wise, "The Cognitum: A Perception-Dependent Concept Needed in Baraminology," in *Proceedings of the Fifth International Conference on Creationism*, ed. Robert L. Ivey (Pittsburgh, PA: Creation Science Fellowship, 2003), 445–56.
[59]Todd C. Wood, "Perspectives on AGEing, a Young-Earth Creation Diversification Model," in *Proceedings of the Fifth International Conference on Creationism*, ed. Ivey, 479–90.
[60]Don Batten, "Teeth Developing in Bird Embryos—Does It Prove Evolution?," *TJ* 17, no. 2 (2003): 11–12.
[61]Matthew Murdock, "Aegyptopithecus, the Egyptian Ape," *TJ* 18, no. 1 (2004): 105–111.
[62]___, "*Sahelanthropus tchadensis*—The Ambiguous Ape," *TJ* 18, no. 3 (2004): 110–15.
[63]Todd C. Wood, *A Creationist Review and Preliminary Analysis of the History, Geology, Climate, and Biology of the Galápagos Islands, CORE Issues in Creation* 1 (2005): 1–241.
[64]Jerry Bergman, "Darwinism and the Deterioration of the Genome," *CRSQ* 42, no. 2 (2005): 104–15.
[65]Alan Gillen and Frank Sherwin, "The Origin of Bubonic Plague," *Journal of Creation* (hereafter *JC*) 20, no. 1 (2006): 7–8.
[66]Andrew Lamb, "CCR5-delta32: A Very Beneficial Mutation," *JC* 20, no. 1 (2006): 15.
[67]Matthew Murdock, "These Apes Were Made for Walking: The Pelves of *Australopithecus afarensis* and *Australopithecus africanus*," *JC* 20, no. 2 (2006): 104–12.
[68]Yingguan Liu and Dan Moran, "Do New Functions Arise by Gene Duplication?," *JC* 20, no. 2 (2006): 82–89.
[69]J. R. Lucas and T. C. Wood, "The Origin of Viral Disease: A Foray into Creationist Virology," *OPBSG* 8 (2006): 13.
[70]Jerry Bergman, "Lack of Fossil Evidence for Arthropod Evolution Is a Major Difficulty for Neo-Darwinism," *CRSQ* 43, no. 4 (2007): 222–30.
[71]Luke Kim, "Accumulation of Mutations: Cancer or Molecule-to-Man Evolution?," *JC* 21, no. 2 (2007): 77–81.
[72]Alex Williams, "Astonishing DNA Complexity Demolishes Neo-Darwinism," *JC* 21, no. 3 (2007): 111–17.
[73]Todd C. Wood, "Introduction: Wrestling with Evil," *OPBSG* 10 (2007): 3–4.
[74]J. P. Baldwin, "Toward a Pre-lapsarian and Post-lapsarian Biblical Philosophy of Nature," *OPBSG* 10 (2007): 7.
[75]T. C. Wood, "The Origin of Pathogenic Bacteria by Degeneration or Design," *OPBSG* 10 (2007): 8–9.
[76]A. L. Gillen and R. Hubbard, "Developing *Serratia marcescens* as a Model to Elucidate Aspects of Germ Genesis Exemplified by *Mycobacterium leprae*," *OPBSG* 10 (2007): 13.
[77]Alan L. Gillen, "Using *Serratia marcescens* as a Model to Elucidate Aspects of Germ Genesis in Bacteria," abstract in "Proceedings of the Microbe Forum, June 2007," ed. Joe Francis and Georgia Purdom, *Answers Research Journal* (hereafter *ARJ*) 1 (January 9, 2008): 3.
[78]Ira S. Loucks, "Pathogenicity Tools and Mycotoxins: In the Beginning or after the Fall?," abstract in "Proceedings of the Microbe Forum, June 2007," ed. Francis and Purdom, 5.
[79]Alan L. Gillen, "Microbes and the Days of Creation," *ARJ* 1 (January 16, 2008): 7–10.
[80]Jean K. Lightner, "Karyotype Variability within the Cattle Monobaramin," *ARJ* 1 (June 11, 2008): 77–88.
[81]___, "Genetics of Coat Color I: The Melanocortin 1 Receptor (MC1R)," *ARJ* 1 (October 8, 2008): 109–16.
[82]Luke Kim, "Bacterial Attenuation and Its Link to Innate Oncolytic Potential: Implications for Creation and the Fall," *ARJ* 1 (October 15, 2008): 117–22.
[83]Jerry Bergman, "Evolution and the Origin of Human Language," *CRSQ* 45, no. 2 (2008): 109–19.
[84]John Sanford, John Baumgardner, Wesley Brewer, Paul Gibson, and Walter ReMine, "Using Numerical Simulation to Test the Validity of Neo-Darwinian Theory," in *Proceedings of the Sixth International Conference on Creationism*, ed. A. A. Snelling (Pittsburgh, PA: Creation Science Fellowship, 2008), 165–75.
[85]Kevin L. Anderson and Georgia L. Purdom, "A Creationist Perspective of Beneficial Mutations in Bacteria," in *Proceedings of the Sixth International Conference on Creationism*, ed. Snelling, 73–86.
[86]John Baumgardner et al., "Mendel's Accountant: A New Population Genetics Simulation Tool for Studying Mutation and Natural Selection," in *Proceedings of the Sixth International Conference on Creationism*, ed. Snelling, 87–98.
[87]Jerry Bergman, "Progressive Evolution or Degeneration?," in *Proceedings of the Sixth International Conference on Creationism*, ed. Snelling, 99–110.
[88]Robert W. Carter, Dan Criswell, and John Sanford, "The 'Eve' Mitochondrial Consensus Sequence," in *Proceedings of the Sixth International Conference on Creationism*, ed. Snelling, 111–16.
[89]Shaun Doyle, "Vestigial Arguments: Remnants of Evolution," *JC* 22, no. 2 (2008): 40–42.
[90]Alex Williams, "Facilitated Variation: A New Paradigm Emerges in Biology," *JC* 22, no. 1 (2008): 85–92.
[91]___, "Mutations: Evolution's Engine Becomes Evolution's End!," *JC* 22, no. 2 (2008): 60–66.
[92]Leonard Brand, "A Critique of Current Anti-ID Arguments and ID Responses," *Origins* 63 (2008): 5–33.
[93]Tom Hennigan, "Toward an Understanding of Arbuscular Mycorrhizal Fungi: Implications for Godly Stewardship and Sustainable Agriculture," *ARJ* 2 (February 18, 2009): 21–28.
[94]Yingguang Liu and Charles Soper, "The Natural History of Retroviruses: Exogenization vs. Endogenization," *ARJ* 2 (September 30, 2009): 97–106.

[95]Frank Sherwin, "A Possible Function of *Entamoeba histolytica* in the Creation Model," *ARJ* 2 (October 14, 2009): 117–21.
[96]Ira S. Loucks, "Fungi from the Biblical Perspective: Design and Purpose in the Original Creation," *ARJ* 2 (October 21, 2009): 123–31.
[97]Georgia Purdom, "The Role of Genomic Islands, Mutation, and Displacement in the Origin of Bacterial Pathogenicity," *ARJ* 2 (October 28, 2009): 133–50.
[98]Yingguang Liu, "Did Gene Duplication Produce Gene Families?," *CRSQ* 45, no. 3 (2009): 179–87.
[99]Jerry Bergman, "Evidence for the Lack of Snake Evolution," *CRSQ* 45, no. 4 (2009): 258–68.
[100]Per A. Larssen, "Mutation and Natural Selection: The Central Dogma of Neo-Darwinian Evolution," *CRSQ* 45, no. 4 (2009): 271–81.
[101]Peter Borger, "The Design of Life: Part 4—Variation-Inducing Genetic Elements and Their Function," *JC* 23, no. 1 (2009): 107–14.
[102]Anne Habermehl, "Those Enigmatic Neanderthals: What Are They Saying? Are We Listening?," *ARJ* 3 (January 13, 2010): 1–21.
[103]Jean K. Lightner, "Comparative Cytogenetics and Chromosomal Re-arrangements," *JC* 24, no. 1 (2010): 6–8.
[104]Jonathan Sarfati, "*Darwinopterus* vs Dawkins," *JC* 24, no. 1 (2010): 43–47.
[105]Brian Thomas, "Cell Systems—What's Really Under the Hood Continues to Drop Jaws," *JC* 24, no. 2 (2010): 13–15.
[106]Shaun Doyle, "Photosynthetic Sea Slugs: An Evolutionary Dilemma," *JC* 24, no. 3 (2010): 10–12.
[107]___, "Lizards Moving from Eggs to Live Birth: Evolution in Action?," *JC* 25, no. 1 (2011): 16–18.
[108]Robert W. Carter, "Can Mutations Create New Information?," *JC* 25, no. 2 (2011): 92–98.
[109]Shaun Doyle, "The Diminishing Returns of Beneficial Mutations," *JC* 25, no. 3 (2011): 8–10.
[110]Jeffrey P. Tomkins, "Alleged Human Chromosome 2 'Fusion Site' Encodes an Active DNA Binding Domain inside a Complex and Highly Expressed Gene-Negating Fusion," *ARJ* 6 (October 16, 2013): 367–75.
[111]Jerry Bergman, "The Origins and Genetic Functions of Pseudogenes," *CRSQ* 49, no. 4 (2013): 308–18.
[112]Christopher L. Rupe and John C. Stanford, "Using Numerical Simulation to Better Understand Fixation Rates, and Establishment of a New Principle: Haldane's Ratchet," in *Proceedings of the Seventh International Conference on Creationism*, ed. Robert E. Walsh (Pittsburgh, PA: Creation Science Fellowship, 1998).
[113]Mike R. Arneigh, "It's a Small World—MicroRNA Cuts Evolution Down to Size," *JC* 27, no. 2 (2013): 85–90.
[114]Jean O'Micks, "Small Genome Size of *Utricularia gibba* Problematic for Evolution but Not Creation," *JC* 27, no. 3 (2013): 4–6.
[115]Peer Terborg, "The 'VIGE-first Hypothesis'—How Easy It Is to Swap Cause and Effect," *JC* 27, no. 3 (2013): 105–12.
[116]Jeffrey P. Tomkins, "The Human *GULO* Pseudogene—Evidence for Evolutionary Discontinuity and Genetic Entropy," *ARJ* 7 (April 2, 2014): 91–101.
[117]Alex Williams, "Human Genome Decay and the Origin of Life," *JC* 28, no. 1 (2014): 91–97.
[118]Philip Robinson, "Cactus Spines, Sharper Than You May Think!," *JC* 28, no. 2 (2014): 9–11.
[119]J. Blaschke, "Ancestral State Reconstruction as a New Method for Identifying Baramins of Pathogens and Parasites," *Journal of Creation Theology and Science, Series B: Life Sciences* 4 (2014): 23–24.
[120]Yingguang Liu, "Cyclic Selection in HIV–1 Tropism: Microevolution That Is Going Nowhere," *ARJ* 8 (April 22, 2015): 199–202.
[121]___, "Mutations of the *nef* Gene Make HIV-1 More Virulent," *ARJ* 8 (June 17, 2015): 323–26.
[122]___, "Is HIV-1 Losing Fitness Due to Genetic Entropy?," *ARJ* 8 (July 1, 2015): 339–51.
[123]Alan Gillen, Jason Conrad, and Michael Cargill, "The Genesis and Emergence of Community-Associated Methicillin-Resistant *Staphylococcus aureus* (CA-MRSA): An Example of Evolution in Action?," *ARJ* 8 (October 14, 2015): 391–401.
[124]Change Tan, "Using Taxonomically Restricted Essential Genes to Determine Whether Two Organisms Can Belong to the Same Family Tree," *ARJ* 8 (November 4, 2015): 413–35.
[125]Peter M. Murphy, "Understanding Open Questions on the Origin of Life," *CRSQ* 52, no. 2 (2015): 136–45.

Discussion

During data collection for this study, it became evident that CS authors frequently employ idiosyncratic usage of evolution-related terms, using the terms in ways that mainstream biologists do not. For example, several CS authors insisted that a structure must be completely functionless to be called vestigial. In contrast, mainstream biologists have long maintained that a reduced structure is vestigial, even if it retains a minor function or functions, as long as it has lost a major function or functions.[15] As Darwin put it in his discussion of vestigial structures (which he called "rudimentary" structures), "An organ serving for two purposes, may become rudimentary or utterly aborted for one, even the more important purpose; and remain perfectly efficient for the other."[16] And as Charles Brues noted in 1903, insect wings that have "become vestigial to such an extent that they are no longer available for … flight" in some cases "have suddenly developed characters that make them of use in some other direction."[17] Nevertheless, several CS authors cite any known function in a vestigial structure as evidence that the structure is not truly vestigial or that no truly vestigial structures exist.[18]

Similarly, some insist that non-coding DNA cannot be considered vestigial because, in some cases, it has a known function,[19] and, in other cases, a function might be found in the future.[20] From the standpoint of mainstream biology, such arguments are nonsensical, because functionlessness is not part of the definition of vestigiality.[21] One CS author argued that if any truly functionless structure were ever found, it would be evidence of degeneration, hence special creation.[22] However, heritable changes of any kind, degenerate or not, are congruent with the evolutionary paradigm and are therefore not evidence against it.

Another frequent example of idiosyncratic usage is restriction of the term "evolution" only to heritable changes that cause the addition, augmentation, or improvement of biological structures—as opposed to heritable changes that cause deletion, degeneration, or vestigialization of biological structures.[23] For example, one author argued that vestigial septa in cephalopod shells are "not supportive of evolution" but "may be a genetic-code remnant of the more conchiferous design employed by God elsewhere."[24] In other words, such septa were derived from more fully developed septa in the shells of these animals' ances-

tors, but the change should not be called "evolution" because it was degenerative. In contrast, mainstream biologists employ a broader definition of evolution and acknowledge heritable changes in general as evolution, whether those changes are degenerative or not. Nevertheless, unlike mainstream biologists, CS authors usually restrict the term "evolution" to additive or augmentative changes. For degenerative changes, such authors use the term "devolution,"[25] a term absent from mainstream biology.

As a general rule, CS authors recoil at the suggestion that vestigial structures exist. One CS author even asserted that the existence of vestigial organs would support creationism but denied their existence nevertheless.[26] However, a few CS authors have acknowledged the existence of vestigial, "rudimentary," or "degenerative" structures,[27] including vestigial genetic sequences.[28] One such author took the position that the vestigial hindlimbs and pelves of extant whales and the small hindlimbs of fossil archaeocete whales (from sediments that he considered post-Flood) indicate that the members of the whale "kind" aboard the Ark had legs and may even have been terrestrial.[29] Two authors frankly acknowledged vestigial structures as a problem for the idea of special creation, proffering the example of mouthparts in insects that do not eat as an example of something that one would not expect God to create.[30] However, according to a subsequent author, this problem is solved by the idea of "devolution," which can cause vestigialization of structures that were created with full function.[31]

Two authors claimed that science has discarded the idea of vestigial structures, arguing that the dwindling of lists of vestigial structures in textbooks through the years, reflects a disowning of the concept by scientists.[32] However, a recent study by mainstream biologists tested that claim and found that it is incorrect. Despite small lists of vestigial structures in textbooks, scientists have explicitly identified hundreds of examples of biological structures as vestigial in the primary scientific literature of the current century.[33]

Some CS authors waxed creative in their functional explanations of structures that mainstream biologists recognize as vestigial. For example, one author explained human ear muscles not as vestigial structures but as pre-adaptations "just in case." He supported this argument by citing the example of an individual whose ear muscles helped him after he lost eardrum function.[34]

Some CS authors pointed out that male nipples and other structures that are functional in only one sex were presumably never functional in the other sex; because such structures are not degenerate they should not be called vestigial.[35] This is, in fact, correct. Although male nipples are sometimes listed as vestigial structures,[36] they are not the degenerate remnants of ancestrally lactiferous male nipples and therefore do not fit the definition of vestigiality. Mainstream biologists would therefore do well to heed these CS authors' point and cease calling male nipples vestigial.

Several twentieth-century CS authors invoked degeneration as an explanation for the morphological features of extinct species of *Homo*.[37] Such authors claimed that *Homo erectus* and *Homo neanderthalensis* were the degenerate descendants of more-ancient *Homo sapiens* and that the ape-like features of *H. erectus* and *H. neanderthalensis* represent degeneration rather than an ancestral state. Two authors even included australopithecine-grade hominids in the list of degenerate human populations.[38] Those two authors claimed that the fossil record shows a pattern in which "degenerate" forms of humanity (*H. erectus*, *H. neanderthalensis*, and australopithecines) are found mainly at the periphery of the Old World, whereas ancient urban populations in the center of the Old World exhibit "advanced" (i.e., undegenerate, as originally created) morphology. These authors explained this by positing that urban existence slowed down the process of degeneracy, enabling settled populations to retain "advanced" morphology, whereas nomads wandering away from Ararat after the Flood gained degenerate morphology, with the greatest degree of degeneracy occurring in the populations that wandered furthest.

Another author identified *H. erectus* and *H. neanderthalensis* as "Hamites" (descendants of Noah's son Ham) and described Hamites as degenerate human populations.[39] He noted that across Eurasia, *H. erectus* and *H. neanderthalensis* remains are found in stratigraphically lower (hence, older) strata than are the remains of modern *H. sapiens*, and to explain this he posited that the descendants of Ham had spread throughout the globe before the descendants of Noah's sons Japheth and Shem did. Interestingly, mainstream paleoanthropologists agree that these

data indicate that *H. erectus* and *H. neanderthalensis* spread across Eurasia before *H. sapiens* did. Mainstream scientists disagree, however, with the identification of the extinct species as descendants of a specific son of Noah or of any member of *H. sapiens*, because no remains of *H. sapiens* are known from strata older than those of the extinct species of *Homo*.

Citation of the morphology of extinct species of *Homo* as examples of biological degeneration dropped to almost zero after the 1970s (fig. 1), and the last such citation was in 1997.[40] However, occasional mention of physiological degeneration, particularly in relation to lifespan, has continued into the present century. A few CS authors list—as an example of physiological degeneracy—the shorter lifespans of post-Flood humanity in comparison to pre-Flood lifespans of centuries, as recorded in Genesis.[41] The earliest such listing was in 1978, the latest in 2009.[42]

One CS author provided an interesting spin on degeneration as applied to extinct hominids. Rather than positing that australopithecines are degenerate humans, he posited that they represent the ancestral form of the ape "kind." He therefore explained the quadrupedal knuckle-walking of today's apes as the result of degeneration from the upright locomotion of their australopithecine "ancestors."[43]

Several twenty-first-century CS authors explain pathogenicity of microbes and the parasitic lifestyle of other organisms—both of which are incompatible with a "very good" creation[44]—as a result of degeneration. According to these authors, all viruses and organisms that are now pathogens or parasites were originally harmless, and in some cases may have been beneficial symbionts, and pathological features appeared as a result of genomic deterioration.[45] The CS explanation of pathogenicity as a result of degeneration is relatively new, with the earliest such explanation appearing in 2001.[46]

Interestingly, evolutionary biologists agree that the reduced genomes of some pathogenic bacteria are the results of gene loss. However, reduced genomes resulting from gene loss occur in beneficial symbiotic bacteria also: this indicates that this genomic decay is related to dependency on a host and not to pathogenicity alone.[47] Similarly, genome size reduction due to gene loss is common among eukaryotic parasites including protozoans, fungi, and invertebrates,[48] but the same is also the case in beneficial eukaryotic endosymbionts.[49] Because genomic reduction is therefore related to host-dependence in general, it seems that within the CS paradigm genomic reduction would have occurred in endosymbiotic microbes even without the Fall of humankind and the resulting Curse upon nature. It will therefore be interesting to see whether future CS articles address this issue and attempt to explain genomic reduction in beneficial endosymbionts.

Six CS authors gave examples of apparently beneficial mutations that they claimed represented genomic degeneration. One author explicitly posited that antibiotic resistance in a bacterium was the incidental result of a mutation that involved a loss of genetic information.[50] Another pointed out that the loss of wings in insects inhabiting windy places is advantageous but is nevertheless an example of morphological degeneration.[51] The others identified advantageous mutations in bacteria and humans as incidental results of genomic deterioration.[52]

The topics of vestigial structures and biological degeneration make for a useful introduction to the fascinating world of creation science. Perplexingly, through half a century, CS authors have maintained a general consensus that all "created kinds" of organisms have undergone degenerative changes, and they have simultaneously maintained a general consensus that vestigial biological structures do not exist. Because the claim for biological degeneration implies the existence of vestigial structures, CS authors' denial of their existence is incongruous. It will be interesting to see whether CS authors recognize this internal inconsistency in future CS literature or whether this mutually contradictory pair of claims will continue to persist. ⌖

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Notes

[1]Allan Mazur, "Believers and Disbelievers in Evolution," *Politics and the Life Sciences* 23, no. 2 (2005): 55–61; Jon D. Miller, Eugenie C. Scott, and Shinji Okamoto, "Public Acceptance of Evolution," *Science* 313 (2006): 765–66.

[2]In the Gospels, Jesus defied the literal sense of regulations from the Pentateuch (Matt. 5:38, 19:3–9; Mark 7:14–19, 10:2–12; Luke 16:18; John 8:1–11) and yet mandated that the entire Law should be followed (Matt. 5:17–19); this seeming contradiction is resolved if he meant that the Law should be followed in a nonliteral sense. In his New Testament epistles, Paul criticized a Jewish faction in the early church that promoted a literal interpretation of the Pentateuch (Galatians 3–5; Colossians 2; 1 Timothy 1; Titus 1–3; see also Acts 15). Paul advocated figurative interpretation of the entire Pentateuch and argued against interpreting Genesis and the rest of the Pentateuch literally (Rom. 2:29, 3:28–31; 1 Cor. 10:1–11; Gal. 3:7, 29; Eph. 5:31–33; Col. 2:16–17; Heb. 3:7–4:11, 9:7–9), even going so far as to call the Pentateuch narratives "myths" (1 Tim. 1:4, 4:7; Titus 1:14). For further explanation, including elaboration on the characterization of Pentateuch narratives as "myths" by Paul and the Apostolic Fathers, see Phil Senter, "Christianity's Earliest Recorded Heresy and Its Relevance to Christian Acceptance of Scientific Findings," *Thinking about Religion,* online journal of the North Carolina Religious Studies Association (forthcoming).

[3]Donald Prothero, *Evolution: What the Fossils Say and Why It Matters* (New York: Columbia University Press, 2007); Felix Gradstein, James Ogg, and Alan Smith, *A Geologic Time Scale 2004* (Cambridge: Cambridge University Press, 2014).

[4]Numerous examples are given in Tom McIver, *Anti-Evolution: An Annotated Bibliography* (Jefferson, NC: McFarland, 2008).

[5]Ibid.

[6]John C. Whitcomb and Henry M. Morris, *The Genesis Flood,* 5th ed. (Phillipsburg, NJ: Presbyterian and Reformed Publishing, 1961).

[7]Chris McGowan, *In the Beginning … A Scientist Shows Why the Creationists Are Wrong* (Buffalo, NY: Prometheus Books, 1984), 58–67; Prothero, *Evolution: What the Fossils Say and Why It Matters*, 60–64; Mark Isaak, *The Counter-Creationism Handbook* (Westport, CT: Greenwood Publishing, 2005), 134–35, 237–38. See also Graeme Finlay, "Human Evolution: How Random Process Fulfils Divine Purpose," *Perspectives on Science and Christian Faith* 60, no. 2 (2008): 103–14; Daniel C. Harlow, "After Adam: Reading Genesis in an Age of Evolutionary Science," *Perspectives on Science and Christian Faith* 62, no. 3 (2010): 179–95; Patrick Franklin, "Understanding the Beginning in Light of the End: Eschatological Reflections on Making Theological Sense of Evolution," *Perspectives on Science and Christian Faith* 66, no. 3 (2014): 154–70.

[8]Walter E. Lammerts, "Introduction," *Creation Research Society Annual* (hereafter *CRSA*) 1 (1964): 1–2.

[9]Ronald L. Numbers, *The Creationists* (Berkeley, CA: University of California Press, 1992), 214.

[10]For example, Don Batten and Jonathan Sarfati, *15 Reasons to Take Genesis as History* (Brisbane, Australia: Creation Ministries International, 2006); Ken Ham, ed., *The New Answers Book 3* (Green Forest, AR: Master Books, 2009); Michael J. Oard, *Dinosaur Challenges and Mysteries* (Atlanta, GA: Creation Ministries International, 2011); Ken Ham, ed., *The New Answers Book 4* (Green Forest, AR: Master Books, 2013).

[11]Phil Senter et al., "Vestigial Biological Structures: A Classroom-Applicable Test of Creationist Hypotheses," *American Biology Teacher* 77, no. 2 (2015): 99–106; Phil Senter and John G. Moch, "A Critical Survey of Vestigial Structures in the Postcranial Skeletons of Extant Mammals," *PeerJ* 3, no. e1439 (2015): 1–48.

[12]Senter et al., "Vestigial Biological Structures"; Senter and Moch, "A Critical Survey of Vestigial Structures."

[13]For example, Jonathan Sarfati, *Refuting Evolution 2* (Green Forest, AR: Master Books, 2002); Shaun Doyle, "Vestigial Arguments: Remnants of Evolution," *Journal of Creation* (hereafter *JC*) 22, no. 2 (2008): 40–42; Jerry Bergman, "The Origins and Genetic Functions of Pseudogenes," *Creation Research Society Quarterly* (hereafter *CRSQ*) 49, no. 4 (2013): 308–18; Alan L. Gillen, Jason Conrad, and Michael Cargill, "The Genesis and Emergence of Community-Associated Methicillin-Resistant *Staphylococcus aureus* (CA-MRSA): An Example of Evolution in Action?," *Answers Research Journal* (hereafter *ARJ*) 8 (October 14, 2015): 391–401.

[14]Kevin L. Anderson and Georgia L. Purdom, "A Creationist Perspective of Beneficial Mutations in Bacteria," in *Proceedings of the Sixth International Conference on Creationism*, ed. A. A. Snelling (Pittsburgh, PA: Creation Science Fellowship, 2008), 73.

[15]Charles Darwin, *On the Origin of Species by Means of Natural Selection* (London: John Murray, 1859); Charles T. Brues, "The Structure and Significance of Vestigial Wings among Insects," *Biological Bulletin* 4 (1903): 179–90; William H. Stickel and Lucille F. Stickel, "Sexual Dimorphism in the Pelvic Spurs of *Enygrus*," *Copeia* (1946): 10–12; Armand d'A. Bellairs and Garth Underwood, "The Origin of Snakes," *Biological Reviews* 26 (1951): 193–237; Hiroshi Sekiguchi, Mayumi Moriya, Takeshi Nakayama, and Isao Inouye, "Vestigial Chloroplasts in Heterotrophic Stramenopiles *Pteridomonas danica* and *Ciliophrys infusionum* (Dictyochophyceae)," *Protist* 153 (2002): 157–67; Brian K. Hall, "Descent with Modification: The Unity Underlying Homology and Homoplasy as Seen through an Analysis of Development and Evolution," *Biological Reviews* 78 (2003): 409–33; Paulo C. Simões-Lopes and Carolina S. Gutstein, "Notes on the Anatomy, Positioning and Homology of the Pelvic Bones in Small Cetaceans (Cetacea, Delphinidae, Pontoporiidae)," *Latin American Journal of Aquatic Mammalogy* 3 (2004): 1–6; Senter et al., "Vestigial Biological Structures"; Senter and Moch, "A Critical Survey of Vestigial Structures."

[16]Darwin, *On the Origin of Species*, 451.

[17]Brues, "The Structure and Significance of Vestigial Wings among Insects," 180.

[18]Wilbert Rusch, "Analysis of So-called Evidences of Evolution," *CRSA* 3 (1966): 4–15; John R. Howitt, "Man, the Upright," *CRSA* 5 (1968): 46–48; Willem J. Ouweneel, "The Scientific Character of the Evolution Doctrine," *CRSQ* 8, no. 2 (1971): 109–15; John R. Howitt, "Some Observations on the Science of Nutrition in the Light of the Scriptures," *CRSQ* 9 (1972): 51–53; C. E. A. Turner, "Teleology: Purpose Everywhere," *CRSQ* 9 (1972): 38–40; Harold Armstrong, "Comments on Scientific News and Views," *CRSQ* 9 (1972): 101–39; ___, "Comments on Scientific News and Views," *CRSQ* 9 (1972): 181–83; E. Norbert Smith, "Another Vestigial Structure Found Useful," *CRSQ* 15, no. 4 (1979): 215; George F. Howe, "Postfire Strategies of Two Chaparral Shrubs (Chamise and Ceanothus) Cast Light on Origins," *CRSQ* 19, no. 1 (1982): 3–10; Randall Hedtke, "The Principle of Applied Creation in an Origin Curriculum," *CRSQ* 20 (1983): 44–46; E. Norbert Smith, "To See or Not to See," *CRSQ* 21 (1985): 198; ___, "The Role of Creation Research in Modern Biology," *CRSQ* 22, no. 3 (1985): 105–7; W. R. Bird, "The Postulated Evidence for Macroevolution and Darwinism: Darwinian Arguments and the Disintegrating Neo-Darwinian Synthesis—Part II," *CRSQ* 25, no. 2 (1988): 74–81; J. G. Leslie, "The Hindrance of Evolutionary Terminology to the Teaching of Science," *Creation ex nihilo Technical Journal* (hereafter *CENTJ*) 3, no. 1 (1988): 59–64; L. James Gibson, "Pseudogenes and Origins," *Origins* 21 (1994): 21–108; Jonathan D. Sarfati, "Blood Types and Their Origin," *CENTJ* 11, no. 1 (1997): 31–32; Carl Wieland, "Why a Fly Can Fly Like a Fly," *CENTJ* 12, no. 3 (1998): 260–61; Jerry Bergman, "The Rise and Fall of Haeckel's Biogenetic Law," *CRSQ* 37, no. 2 (2000): 110–22; ___, "Do Any Vestigial Structures Exist in Humans?," *CENTJ* 14, no. 2 (2000): 95–98; Mark H. Armitage and George F. Howe, "The Ultrastructure of Lichen Cells Supports Creation, Not Macroevolution: A Photo Essay and Literature Review—Part II," *CRSQ* 44, no. 2 (2007): 107–18; Doyle, "Vestigial Arguments"; Janet Henriksen, "The Design Paradigm," *JC* 22, no. 2 (2008): 53–59, footnote 21; Jerry Bergman, "Was the Prostate Gland Poorly Designed?," *CRSQ* 44, no. 3 (2008): 230–35; ___, "Evidence for the Lack of Snake Evolution," *CRSQ* 45, no. 4 (2009): 258–70; ___, "*Inherit the Wind*: A Lesson in Distorting History," *ARJ* 3 (March 31, 2010): 61–69; ___, "Whale Evolution: A Whale of a Tale," *CRSQ* 49, no. 2 (2012): 122–34; Tom Hennigan, "An Initial Estimate toward Identifying and Numbering Extant Tuatara, Amphisbaena, and Snake Kinds," *ARJ* 7 (February 19, 2014): 31–47.

[19]Richard D. Lumsden, Paul C. Anders, and Jeffery R. Pettera, "Genetic Information and McCann's Dual Factor Paradigm for Development and Variation," *CRSQ* 29, no. 2 (1992): 63–69; D. J. Batten, "'Junk' DNA (Again)," *CENTJ* 12, no. 1 (1998): 5; Don Batten, "No Joy for Junkies," *TJ* 19, no. 1 (2005): 3; Robert W. Carter, "The Slow, Painful Death of Junk DNA," *JC* 23, no. 3 (2009): 12–13.

[20]Todd C. Wood and David P. Cavanaugh, "A Baraminological Analysis of Subtrive Flaveriinae (Asteraceae: Helenieae) and the Origin of Biological Complexity," *Origins* 52 (2001): 7–27; Timothy G. Standish, "Rushing to Judgment: Functionality in Noncoding or 'Junk' DNA," *Origins* 53 (2002): 7–30; Jerry Bergman, "The Origins and Genetic Functions of Pseudogenes."

[21]Senter et al., "Vestigial Biological Structures."

[22]Ouweneel, "The Scientific Character of the Evolution Doctrine."

[23]G. C. Lockwood, "The Second Law of Thermodynamics and Evolution," *CRSQ* 8 (1971): 8, 23; Willem J. Ouweneel, "Homoeotic Mutants and Evolution," *CRSQ* 12, no. 3 (1975): 141–54; Douglas B. Sharp, "Interdependence in Macromolecule Synthesis: Evidence for Design," *CRSQ* 14, no. 1 (1977): 54–61; Jerry Bergman, "Some Biological Problems with the Natural Selection Theory," *CRSQ* 29, no. 3 (1992): 146–58; C. Wieland, "Lost World of Mutants Discovered," *CENTJ* 10, no. 2 (1996): 172–73; Jean O'Micks, "Small Genome Size of *Utricularia gibba* Problematic for Evolution but Not Creation," *JC* 27, no. 3 (2013): 4–6.

[24]John Woodmorappe, "The Cephalopods in the Creation and the Universal Deluge," *CRSQ* 15, no. 2 (1978): 95.

[25]Hilbert R. Siegler, "The Magnificence of Kinds as Demonstrated by Canids," *CRSQ* 11, no. 2 (1974): 94–97; David P. Licata, "A Unit on Biological Origins for the Secular Classroom," *CRSQ* 16, no. 1 (1979): 60–63; A. J. Jones, "A Creationist Critique of Homology," *CRSQ* 19, no. 3 (1982): 156; Jerry Bergman, "Some Biological Problems with the Natural Selection Theory"; ___, "Mutations and Evolution," *CENTJ* 9, no. 2 (1995): 146–54; ___, "The Transitional Form Problem," *CRSQ* 35, no. 3 (1998): 134–47; David L. Bergman, "Conflict of Atomism and Creationism in History," in *Proceedings of the Fourth International Conference on Creationism,* ed. Robert E. Walsh (Pittsburgh, PA: Creation Science Fellowship, 1998), 53–66; John W. Cuozzo, "What Happens to the Craniofacial Structure of Humans Who Live Past 100 Years? Neanderthal Similarities," in *Proceedings of the Fourth International Conference on Creationism,* ed. Walsh, 103–20; Joseph Masropaolo, "Evolution Is Lethal Antiscience," *CRSQ* 38, no. 3 (2001): 151–58; Jerry Bergman, "Why Mutations Are Lethal to Darwinism," *CRSQ* 38, no. 4 (2002): 181–89; Alan Gillen and Frank Sherwin, "The Origin of Bubonic Plague," *JC* 20, no. 1 (2006): 7–8; Matthew Murdock, "These Apes Were Made for Walking: The Pelves of *Australopithecus afarensis* and *Australopithecus africanus*," *JC* 20, no. 2 (2006): 104–12; Jerry Bergman, "Lack of Fossil Evidence for Arthropod Evolution Is a Major Difficulty for Neo-Darwinism," *CRSQ* 43, no. 4 (2007): 222–31; Ira S. Loucks, "Pathogenicity Tools and Mycotoxins: In the Beginning or after the Fall?," abstract in "Proceedings of the Microbe Forum, June 2007,"*ARJ* 1 (January 9, 2008): 5; ___, "Fungi from the Biblical Perspective: Design and Purpose in the Original Creation," *ARJ* 2 (October 21, 2009): 123–31; Anne Habermehl, "Those Enigmatic Neanderthals: What Are They Saying? Are We Listening?," *ARJ* 3 (August 22, 2010): 1–21; Jonathan Sarfati, "*Darwinopterus* vs Dawkins," *JC* 24, no. 1 (2010): 43–47; Mike R. Arneigh, "It's a Small World—MicroRNA Cuts Evolution Down to Size," *JC* 27, no. 2 (2013): 85–90; Jean O'Micks, "Small Genome Size of *Utricularia gibba* Problematic for Evolution but Not Creation," *JC* 27, no. 3 (2013): 4–6; Yingguang Liu, "Cyclic Selection in HIV-1 Tropism: Microevolution That Is Going Nowhere," *ARJ* 8 (April 22, 2015): 199–202.

[26]Doyle, "Vestigial Arguments."

[27]Henry M. Morris, "The Power of Energy," *CRSA* 1 (1964): 18–23; H. S. Hamilton, "Convergent Evolution—Do the Octopus and Human Eyes Qualify?," *CRSQ* 24, no. 2 (1987): 82–85; John Woodmorappe, "Causes for the Biogeographic Distribution of Land Vertebrates after the

Flood," in *Proceedings of the Second International Conference on Creationism,* ed. Robert E. Walsh (Pittsburgh, PA: Creation Science Fellowship, 1990), 53–66; Kurt P. Wise, "Towards a Creationist Understanding of Transitional Forms," *CENTJ* 9, no. 2 (1995): 216–22; ___, "North American Paleontology Convention 96," *CENTJ* 10, no. 3 (1996): 315–21; M. Aaron, "Discerning Tyrants from Usurpers: A Statistical Baraminological Analysis of Tyrannosauroidea Yielding the First Dinosaur Holobaramin," *ARJ* 7 (November 26, 2014): 463–81.

[28]Pierre Jerlström, "Jumping Wallaby Genes and Post-Flood Speciation," *CENTJ* 14, no. 1 (2000): 9–10.

[29]Kurt P. Wise, "Mammal Kinds: How Many Were on the Ark?," *CORE Issues in Creation* 5 (2009): 129–61.

[30]Robert R. Sanders and George F. Howe, "Insects Indicate Creation," *CRSQ* 22, no. 4 (1986): 166–70.

[31]Woodmorappe, "Causes for the Biogeographic Distribution of Land Vertebrates after the Flood."

[32]Hilton Hinderliter, "Professor Frick—and the Theory in Stone," *CRSQ* 19, no. 3 (1982): 175–78; J. Bergman, "Some Biological Problems with the Natural Selection Theory"; ___, "*Inherit the Wind*."

[33]Senter et al., "Vestigial Biological Structures."

[34]John Kaplan, "Functional External Ear Muscles," *CRSQ* 30 (1993): 90.

[35]Jones, "A Creationist Critique of Homology"; Hedtke, "The Principle of Applied Creation in an Origin Curriculum"; Linda K. Walkup, "Junk DNA: Evolutionary Discards or God's Tools?," *CENTJ* 14, no. 2 (2000): 18–30; Jerry Bergman, "Is the Human Male Nipple Vestigial?," *TJ* 15, no. 2 (2001): 38–41.

[36]Darwin, *On the Origin of Species*, 450; G. Wilson, "Biological and Social Aspects of Female Social Functioning," in *Current Issues in Clinical Psychology,* vol. 3, ed. Eric Karas (New York: Plenum, 1987), 65–72; Michael Shermer, *Why Darwin Matters: The Case against Intelligent Design* (New York: Henry Holt, 2006), 18.

[37]William J. Tinkle, "Evolution: The Paradox of a Century," *CRSQ* 1 (1964): 8–9; Rusch, "Analysis of So-called Evidences of Evolution"; Arthur C. Custance, "Fossil Man in Light of the Record in Genesis," *CRSA* 5 (1968): 5–22; Melvin A. Cook, "Radiological Dating and Some Pertinent Applications of Historical Interest: Do Radiological 'Clocks' Need Repair?," *CRSQ* 5 (1968): 69–77; William J. Tinkle, "The Ancestry of Man," *CRSA* 5 (1968): 42–45; R. Daniel Shaw, "Fossil Man: Ancestor or Descendant of Adam?," *CRSQ* 6, no. 4 (1970): 172–81; Ouweneel, "The Scientific Character of the Evolution Doctrine"; Harold W. Clark, "Fossil Man and the Creation Concept," *CRSQ* 11, no. 2 (1974): 115–20; John N. Moore, "On Methods of Teaching Origins: A Progress Report," *CRSQ* 13, no. 1 (1976): 46–55; Ken Guenter, "Implications of Palaeolithic Stratigraphy for Creationist Models of Prehistory," *CRSQ* 18, no. 3 (1981): 168–70; Malcolm Bowden, "*Homo erectus*—A Fabricated Class of 'Ape-Men,'" *ENTJ* 3 (1988): 152–53; Celedonio García-Pozuelo-Ramos, "Taxonomy of Primates," *CRSQ* 34, no. 2 (1997): 93–102.

[38]Shaw, "Fossil Man"; Clark, "Fossil Man and the Creation Concept."

[39]Custance, "Fossil Man in Light of the Record in Genesis."

[40]García-Pozuelo-Ramos, "Taxonomy of Primates."

[41]James E. Strickling, "Creation, Evolution and Catastrophism," *CRSQ* 15, no. 1 (1978): 12–14; Carl Wieland, "Decreased Lifespans: Have We Been Looking in the Right Place?," *CENTJ* 8, no. 2 (1994): 138–41; Bergman, "The Transitional Form Problem"; Cuozzo, "What Happens to the Craniofacial Structure of Humans Who Live Past 100 Years?"; Jerry Bergman, "The Life Clock and Paley's Watch: The Telomeres," *CRSQ* 37, no. 3 (2000): 176–83; Per A. Larssen, "Mutation and Natural Selection: The Central Dogma of Neo-Darwinian Evolution," *CRSQ* 45, no. 4 (2009): 271–81.

[42]Strickling, "Creation, Evolution and Catastrophism"; Larssen, "Mutation and Natural Selection."

[43]Murdock, "These Apes Were Made for Walking."

[44]Genesis 1:31.

[45]Don Batten, "Food Scare Leads to Design Discovery," *TJ* 15, no. 1 (2001): 13–14; Gillen and Sherwin, "The Origin of Bubonic Plague"; Loucks, "Pathogenicity Tools and Mycotoxins"; Frank Sherwin, "A Possible Function of *Entamoeba histolytica* in the Creation Model," *ARJ* 2 (October 14, 2009): 117–21; Georgia Purdom, "The Role of Genomic Islands, Mutation, and Displacement in the Origin of Bacterial Pathogenicity," *ARJ* 2 (October 28, 2009): 133–50; Gillen et al., "The Genesis and Emergence of Community-Associated Methicillin-Resistant *Staphylococcus aureus* (CA-MRSA)."

[46]Batten, "Food Scare Leads to Design Discovery."

[47]Nancy A. Moran, "Tracing the Evolution of Gene Loss in Obligate Bacterial Symbionts," *Current Opinion in Microbiology* 6 (2003): 512–18; Lisa Klasson and Siv G. E. Andersson, "Evolution of Minimal-Gene-Sets in Host-Dependent Bacteria," *Trends in Microbiology* 12 (2004): 37–43; Andrés Moya, Juli Peretó, Rosario Gil, and Amparro Latorre, "Learning How to Live Together: Genomic Insights into Prokaryote-Animal Symbioses," *Nature Reviews Genetics* 9 (March 2008): 218–29; Nancy A. Moran, Heather J. McLaughlin, and Rotem Sorek, "The Dynamics and Time Scale of Ongoing Genomic Erosion in Symbiotic Bacteria," *Science* 323, no. 5912 (2009): 379–82.

[48]Michaël D. Katinka et al., "Genome Sequence and Gene Compaction of the Eukaryote Parasite *Encephalitozoon cuniculi*," *Nature* 414, no. 6862 (2001): 450–53; E. Sally Chang et al., "Genomic Insights into the Evolutionary Origin of Myxozoa within Cnidaria," *Proceedings of the National Academy of Sciences of the United States of America* 112, no. 48 (2015): 14912–17; Mark Burke et al., "The Plant Parasite *Pratylenchus coffeae* Carries a Minimal Nematode Genome," *Nematology* 17, no. 6 (2015): 621–37.

[49]Todd C. LaJeunesse et al., "*Symbiodinium* (Pyrrhophyta) Genome Sizes (DNA Content) Are Smallest among Dinoflagellates," *Journal of Phycology* 41, no. 4 (2005): 880–86; Tomonori Sato, Chikako Nagasato, Yoshiaki Hara, and Taizo Motomura, "Cell Cycle and Nucleomorph Division in *Pyrenomonas helgolandii* (Cryptophyta)," *Protist* 165, no. 2 (2014): 113–22.

[50]Leonard Brand, "A Critique of Current Anti-ID Arguments and ID Responses," *Origins* 63 (2008): 5–33.

[51]Carl Wieland, "Variation, Information and the Created Kind," *CENTJ* 5, no. 1 (1991): 42–47.

[52]Ibid.; Don Batten, "Teeth Developing in Bird Embryos—Does It Prove Evolution?," *TJ* 17, no. 2 (2003): 11–12; Andrew Lamb, "CCR5-delta32: A Very Beneficial Mutation," *JC* 20, no. 1 (2006): 15; Anderson and Purdom, "Creationist Perspective of Beneficial Mutations in Bacteria."

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Sy Garte

Article

Teleology and the Origin of Evolution

Sy Garte

Darwinian evolution is not synonymous with change; it is a uniquely biological process. The biochemical mechanism of evolution is distinct from the observations made by Darwin on hereditable variation and natural selection. The key to biological evolution is a tight linkage between inheritable genotype and gene-directed phenotype, which allows the phenotype to be the target of selection. It is theoretically possible for some forms of life to exist without evolution; thus, the origin of life and the origin of evolution are two separate research questions. The classical problem of teleology in biology may be approached by a close examination of the mechanism behind the universal genotype-phenotype linkage: the protein synthesis or translation system. This solution to the problem of converting nucleic acid chemistry into protein chemistry may be the fundamental root of teleonomy and inherent teleology in living organisms.

If we believe that God created life to evolve to humans as image bearers,[1] then we can think of God's will to have living animals capable and desirous of a relationship with him as the final cause of evolution. However, some Christian thinkers, both currently and in the past, have found it difficult to reconcile Darwin's theory of evolution with the theological view that God created our universe and all life purposefully. Claims from biologists that evolution is a blind process, reliant on random mutations, and without any apparent direction or purpose other than to produce creatures able to survive in a particular environmental niche do not seem to be consistent with the Christian concept of an actively creative God who used evolution to produce creatures able to worship him. Most scientists and philosophers, including Christians, have been skeptical at best about the idea of purpose in evolution, and some have claimed that any form of teleology is contrary to the very fabric of Darwinism.

However, there are indications that evolutionary biology itself is moving toward a far more complex view of how biological variation is produced,[2] and a good deal of evidence has shown that there are, very likely, sufficient constraints on evolutionary developments to allow for at least some degree of direction.[3] I will, in what follows, lay out a case for a positive view of the role of teleology in the progress of life based on our scientific knowledge of the origins of evolution.

Evolution in Biology and Elsewhere

Evolution is a form of change, and change is a universal feature of our universe. Stars form and explode, planets collide with asteroids, black holes absorb huge amounts of matter, and galaxies move farther from each other. On our planet change has always been the rule: changing climates, changing atmospheres, changing landscapes. When Charles Lyell and Charles Darwin looked at natural history, they saw change as a key feature of geology and biology, respectively.

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Habitats changed and species went extinct. Darwin used his observations of living forms—as well as his knowledge of changes made by humans to plants and animals—to propose his theory of evolution of life based on natural selection of the most fit variants in a population.[4]

It has become a commonplace theme that evolution by natural selection is a universal phenomenon that not only leads to the origin of new species, but also to changes in human societies, technology, language, culture, and many other areas. We now talk about the evolution of computer programs, music-playing devices, memes, and just about everything else—and it is, of course, true that selection can operate outside the biological evolutionary framework. But selection alone is not sufficient for a process to be considered equivalent to Darwinian evolution.

Chemical selection allows for molecules that are more resistant to hydrolysis to survive longer. Everything from RNA molecules[5] to computer programs[6] has exhibited selection, in that individuals with higher fitness tend to survive longer and eventually dominate their populations. Some have pointed to all of technology as being subject to natural selection,[7] as competition between brands leads to innovative and improved types of computers, cell phones, and so on. There is extinction (sometime even mass extinction such as that of all brands of 8-track tape players); there are explosions of brand-new functions (telephones becoming cameras); and there is also slow, steady progress in some lineages in which the basic form and function have hardly changed at all (automobiles, for example). Human societies also evolve through processes that seem quite similar to the model of survival of the fittest described by Darwinian evolution.[8]

But none of this nonbiological change is really Darwinian evolution. In some cases, the selection step is conscious and volitional, arising from choices made by human beings, and is therefore akin to what Darwin knew as artificial selection in the breeding of plants and animals.[9] Technological evolution is removed from the Darwinian paradigm in that devices do not replicate themselves, so the target of selection is not the device but the mind of the consumer and/or the decisions of corporate manufacturers and marketing specialists. Furthermore, there is no Darwinian mechanism that can be applied to the innovation of new technologies.[10]

In reality, and contrary to the assertions of some leading Darwinists, Darwinian evolution by natural selection is a strictly biological theory, and does not apply to any of the myriad of nonbiological examples of change. Evolution by natural selection requires three uniquely biological characteristics before it can operate. These are mortality, inheritance, and genetic variation, each of which is a property of all modern living cells.

Mortality allows for the emergence of new individuals with similar but not identical features. Inheritability is achieved by accurate replication of the genetic informational molecule. Darwinian natural selection requires that the genetic sequence of the replicator is passed on to progeny with enough accuracy so that the selective advantage possessed by the original sequence is still present in the offspring.

Natural selection acts on the phenotype, but only the genotype can be passed from one organism to its progeny by biochemical means;[11] therefore the key to biological evolution is a tight linkage between inheritable genotype and gene-directed phenotype. In modern evolvable life, when an organism inherits a particular genotype, it also inherits the corresponding phenotype that is produced (or coded for) by that genotype. This allows the phenotype of the individual or a group of individuals to be the target of selection imposed by the environment. Advantageous genetic mutations are passed down, increasing the fitness of populations, and eventually creating new species and producing diverse patterns of complexity and adaptation of living beings to their surroundings.[12]

The linkage of genotype and phenotype is an essential characteristic of evolution by natural selection. Once a cell that can connect genotype and phenotype in this way exists, it can begin to evolve—but until we have such a cell, no evolution is possible.

The Origin of Evolution

Since evolution provides an enormous selective advantage to life, it seems to be a very straightforward conclusion that evolution evolved early on, and once in place, non-evolving life forms rapidly went extinct. Therefore, it is generally assumed that the origin of life and the origin of evolution were contemporaneous and inextricably linked together.

It is not at all clear, however, whether the first life forms could evolve, or how evolution first evolved. The mystery of the origin of life should really be called the mystery of the origin of evolution. The origin of evolution is, in fact, the "hard problem" in abiogenesis. It is very difficult to imagine a Darwinian type of evolution that could produce Darwinian evolutionary mechanisms including genetic inheritance, genetic variation, and genotype-phenotype linkage.

The central issue of the origin of evolution is chemistry becoming biology. For that to happen, early life had to solve a very difficult chemical problem: to take one chemical system (nucleic acid chemistry) and have it interact with and provide information to a completely different chemical system (protein and amino acid chemistry).

Life could exist without facing that problem, but it would not evolve. It might change and it might even improve (transiently), but it cannot undergo any kind of long-term Darwinian evolution in which improvements are maintained in succeeding generations unless the chemical system that gets inherited (nucleic acids) can be translated into the chemical system that is the target of evolution (proteins). In other words, there needs to be a chemical link between the genotype and the phenotype for evolution to happen. While there are some affinities between certain amino acids and some arrangements of nucleic acids,[13] the chemistry of DNA and the chemistry of amino acids or proteins are fundamentally different. It is, therefore, worthwhile to further explore the existence of a nucleic acid-to-protein transformation code (the genetic code), and the amazing molecular mechanism that allows the information in the genes to become the characteristics of the cell.

We know that in most cases of biological evolution, new structures or functions start out as rudimentary and are perfected with time. This is called the Continuity Principle.[14] For the replication/translation system, this would imply starting with an error-prone mechanism that gradually improves through natural selection. But if either genotype replication or DNA-to-protein translation were highly error-prone, then evolution as we know it would not occur. Wolf and Koonin discuss "… the formidable difficulty of breaking this transition into incremental steps associated with a biologically plausible selective advantage, thus making the entire transition compatible with the Continuity Principle."[15] These authors postulate that the RNA world could provide an answer to this conundrum, while admitting that "staggering complexity is inherent even in the minimally functional translation system."[16]

This does not, however, rule out other forms of evolution, such as highly error-prone systems, that are still in the process of being elucidated.[17] The possibility that the modern system arose from a more primitive system is strengthened by the fact that the ribosome, a structure at the heart of modern protein synthesis, contains not only proteins but also ribozymes, enzyme-like catalysts made of RNA (see below). This is consistent with theories of a precursor to modern life based on RNA, with no single genotype molecule, and only a few protein enzymes.[18] But there is not enough information currently available to be able to construct a solid theory about the origins of the biochemical mechanisms that provided the modern, universal genotype-phenotype linkage required for evolution to operate.

Leaving aside the question of how the translation system complete with genetic code appeared, we can look at the final working system as the engine of all subsequent Darwinian evolutionary changes, and ask questions about the philosophical implications of such a system existing at the heart of all of biology. How all of this fits into the question of teleological processes in evolution will be discussed below.

Teleology in Biology

The idea of biological progress was attacked by Stephen Jay Gould, who reminded us that there are still more bacteria than everything else combined, by both numbers and mass.[19] And yet, evolutionary progress, in one sense, does appear to be real as attested to by a wide spectrum of thinkers, from Richard Dawkins[20] to Conor Cunningham.[21] While many measures of such progress can be used, the increasing degree of complexity of the most complex creatures is evident throughout the vast period of evolutionary time. Related to evolutionary progress is the concept of teleology.

Early biological theories of change included William Paley's design-based teleology (God as the Designer) and the Aristotelian concept of final causation (the end purpose of the change) as crucial components.

As an example of the latter, it was believed that giraffes kept straining their necks in order to reach the tall leaves, and eventually got longer necks that they passed down to their descendants. The Lamarckian idea that creatures can pass on altered traits to their offspring fit into this teleological view quite nicely.

Several authors have pointed out that one of the most important contributions of Darwin's great theory was to refute the teleological view and to place biology squarely in line with the other sciences, independent of purpose.[22] The Aristotelian concept of telos as the final cause of a chain of events no longer held in the light of natural selection.[23] Darwin's proposal that natural selection is the alternative to purposeful causation (e.g., artificial selection) was the crowning achievement of the effort to take biology out of the realm of the mystical and supernatural.

Almost a century later, when the modern synthesis of evolution and genetics had begun to revitalize Darwinism and led to the birth of neo-Darwinism,[24] teleology in biology was dealt another blow by research into the nature of mutations. Although DNA was yet to be discovered as the genetic molecule, biologists were examining mutations in experimental systems of bacteria to answer questions about purpose and chance in mutation production. The issue was whether bacteria undergo mutations specifically in those genes that would help them survive an environmental stress such as starvation or exposure to toxic drugs. If they do not, the alternative is that mutations are generated randomly and the environment selects those that confer a survival benefit.

Luria and Delbrück seemed to have answered this question with an elegant system called fluctuation analysis.[25] The results of these experiments were clear: mutations were random, and then selected for their relative fitness. This finding contributed to the emerging neo-Darwinian synthesis, with molecular genetics playing the key role in the production of phenotypic variation. It also confirmed the idea that purpose is replaced by chance in the mechanism of the first stage of evolution.[26]

This idea became ingrained in the biological dogma, and as more and more data regarding the nature of genes and how they operate and change became available, the prevailing consensus grew stronger. For most scientists, evolution became a theory that neither required nor admitted to any degree of purpose or design.[27] However, this is a philosophical, rather than an empirically demonstrated scientific position.

But while evolution is blind, inherent teleology is clearly present in the biological world, either as human-like deliberate purpose or as the more automatic form of teleonomy.[28]

Ernst Mayr's definition of teleonomy as a program written in the genes fits well for the vast majority of living organisms, including all of the plants, bacteria, and archaea.[29] It also applies to most animals, including some vertebrates. But for animals with nervous systems that have a degree of complexity allowing for more than simple stimulus-response networks, the extended definition that includes "open" programming starts to become important.[30]

As Alister McGrath points out, agreeing with Mayr, "some criticisms of the notion of 'teleology' in a biological context actually rest on philosophical precommitments, rather than on biological observations." The fact that Darwinism might not disclose any sense of purpose in life does not lead to Dawkins's conclusion that there *is* no purpose to life.[31]

Daniel Dennett says that all living organisms do things *for* a purpose, even if they are oblivious to what that purpose is.[32] Humans—uniquely, he continues—*have* purposes, and are even able to discern the purposes behind the blind process of natural selection that the animal beneficiaries of such purposes are totally unaware of. I think it possible that Dennett (who is, after all, a philosopher) might have been gently chiding some of his anti-theistic scientific colleagues, who tend to lump inherent teleology in the Aristotelian sense (for which natural selection could be considered the final cause) with external teleology as related to God's purpose. This confusion has led to a general rejection of any notion of purpose in biology, and indeed a discomfort with any teleological language,[33] which brings to mind J.B.S. Haldane's famous quote: "Teleology is like a mistress to a biologist: he cannot live without her but he's unwilling to be seen with her in public."[34]

I agree that the roots of biological teleology do not lie in the *action* of evolutionary processes. Instead,

I believe they can be found in the very *fabric* of the evolutionary process. In other words, purpose is built into the central, deepest biochemical meaning of what evolution is. It is therefore inevitable that what we see first as biological teleonomy, and then as human purpose exemplified by free will, will arise as a result of evolution, even though the evolutionary process is not itself teleological. The mechanism of evolution itself represents a purpose, just as, according to Dennett, humans are creatures that represent reasons for action.[35] I am suggesting that, for evolution, purposeful reasons are represented by the genetic code. To understand the rationale behind this suggestion, we need to deconstruct the link between evolution and life.

Is Evolution a Necessity for Life?

The answer depends a great deal on one's working definition of life. Since some definitions include the ability to evolve, the question only makes sense if we use a definition that is as broad and unrestricted as possible. If we use the metabolism-first model of abiogenesis, we can define life according to Sousa et alteri as "the harnessing of chemical energy in such a way that the energy-harnessing device makes a copy of itself."[36]

Terrestrial life began shortly after the young Earth cooled. We know that at some point between 3.5 and 4 billion years ago, the modern form of DNA-based life appeared on Earth. During the entire period of the evolution of life, Earth was in a constant state of geologic and climate flux. In the Archean and Proterozoic eons, which lasted for most of Earth's history, there were a number of extreme ice ages, periods of intense volcanic activity, impacts from meteors and comets, formation and breaking apart of supercontinents, as well as major changes in the composition of the atmosphere, land, and water, and in the temperature and extent of the oceans. All of this continual, slow environmental change was the engine for natural selection-based evolution. Francisco Ayala stressed,

> Environmental diversity and environmental change are responsible for the continuous evolution of natural populations. If life existed in only a single uniform and constant environment, evolution might conceivably have produced a genotype optimally fitted to that environment with no further change.[37]

As a thought experiment, imagine a planet much like Earth, about the same size, with the same amount of gravity, in the habitable zone, with liquid water, following a regular circular or close to circular orbit, with plenty of organic material. Let's also assume that this planet has no plate tectonics and is extremely stable environmentally. It never undergoes major temperature or atmospheric changes, it has little or no seismic activity, and is somehow highly protected from meteor or asteroid impacts. Finally, we can assume that the origin of some primitive organized life form occurs, perhaps as a result of basic principles of energy dissipation[38] or chemically driven reactions.[39]

We might find living cells with a host of metabolic chemistry going on in this world, including energy conversion reactions and synthetic reactions enclosed in a naturally occurring lipid vesicle or cell. We can even think that such a cell might grow in size as more chemical species are added to the cell by ingestion or metabolism. These cells might split in two at a certain point. It is even possible to imagine that some complex macromolecules such as polypeptides might be found in them. Once such a cell was formed, it might survive for a very long period, and if it did divide, the population might grow until checked by limited chemical resources.[40]

Would such a life form further evolve on such a planet? Why should it? Natural selection is very weak when the environment does not change. It is likely that evolution would not happen at all. And in fact, these living cells could be devoid of genes—they could have no DNA, no RNA, no genetic molecules of any kind. If there is no need for evolution, there is no need for genes. The metabolizing cells would just live and metabolize until they died. If they all died, nothing much would happen until another accidental start of life occurred. It is possible to imagine a world like that lasting for billions of years, with no change, no evolution, and no life other than a series of chemical reactions going on in a vesicle. Here is a somewhat different but related speculation from the Committee on the Limits of Organic Life in Planetary Systems:

> The only alternative to evolution for producing diversity would be to have environmental conditions that continuously create different life forms or similar life forms with random and frequent "mistakes" in the synthesis of chemical templates

> used for replication or metabolism. Such mistakes would be equivalent to mutations and could lead to traits that gave some selective advantage in an existing community or in exploiting new habitats. That random process could lead to life forms that undergo a form of evolution without a master information macromolecule, such as DNA or RNA. It is difficult to imagine such life forms as able to "evolve" into complex structures unless other mechanisms, such as symbiosis or cell-cell fusion, are available.[41]

Perhaps life and evolution are not as tightly linked as we think—although on an unstable, constantly changing planet like ours, they must be. The point is that evolution is very special. It is not guaranteed to occur whenever life gets started, and it is, in fact, a much more elaborate and difficult phenomenon to visualize than the appearance of purely metabolic chemical life.

The Molecular Biology of Evolution

We know a great deal of the mechanisms of evolution in modern terrestrial life. Evolution could potentially occur through alternative mechanisms that do not involve a genetic code (as is postulated for RNA world), but for the kind of efficient and adaptive evolution we see around us, a DNA-based code seems ideal.

However, DNA itself does not actually do anything; it is only the repository for information. The information lies in the sequence of the bases in DNA, much like the information in this sentence lies in the sequence of the letters in each word and phrase. The DNA chemical language is read and translated by other chemicals in a process that is now well understood. There is nothing about this process that is outside of the laws of chemistry and physics, but it is a remarkable process, even compared to all of the other complex biochemical processes that occur in every living cell.

In all cellular life forms on Earth, the information in the DNA is copied into RNA with the same sequence as the DNA. This RNA serves as a message (it is called "messenger RNA") and is then used to create the proteins. There is a code by which every group of three bases of DNA and RNA (called a "codon") is translated into a specific amino acid. Thus the base sequence GGG codes for the amino acid Glycine, AAG codes for Lysine, et cetera.

The information contained in the DNA sequence is translated into the correct protein sequence by an exceedingly complex machinery that involves the messenger RNA (mRNA), ribosomes (another form of RNA), and two adapter molecules: an RNA type called transfer RNA (tRNA) and a protein enzyme called aminoacyl-tRNA synthetase (aaRS). There are also many cofactors and proofreading enzymes required for the process to work properly.

The three kinds of RNA involved in this process are fascinatingly different from each other, and very ancient. The mRNA is a long polymer, resembling a miniature single strand of DNA; the ribosomal RNAs are large enzyme-looking structures with bumps and grooves and binding sites; and the tRNA is a small, folded-up molecule with a whole series of different shapes. It is the tRNA that contains a three-base sequence (the "anticodon") that binds to the correct codon on the mRNA.

Each aaRS has a binding site for an amino acid, and another for the tRNA specific for that amino acid. The tRNA is recognized by a part of its shape called the "paracodon." When the amino acid and its tRNA are both bound to the enzyme, the aaRS changes its shape and brings the two molecules together, forming an amino acid-tRNA conjugate.

This conjugate then goes to the ribosome, and the anticodon on the tRNA binds to the codon on the mRNA that is specific for the amino acid now bound to its tRNA. This is the chemical basis for the genetic code. The mRNA and its bound tRNA (with the amino acid attached to it) are bound to a special site on the ribosome. Another amino acid-tRNA conjugate binds to the next codon on the mRNA and lands on the ribosome right next to the first one. The ribosome then links the two adjacent amino acids together in a peptide bond to begin the synthesis of the long protein ("polypeptide") chain. The mRNA then moves along the ribosome, displacing the first tRNA; the second tRNA moves into the first position, and another tRNA (with its amino acid attached) binds to its codon and is added to the growing protein chain. This process then repeats for between several dozen to several hundred times, until the protein with exactly the right amino acid sequence (as determined by the DNA nucleotide sequence) is complete.

So, we have a set of tRNAs that have amino acid-specific codons (from one to six different ones for the different amino acids), which also have a shape that fits into a specific aminoacyl-tRNA synthetase, which also has a binding site for the corresponding correct amino acid. This, in itself, is remarkable. But no less so is the process by which the messenger RNA moves along the ribosome while the protein chain is grown. And then, of course, there is the question of the genetic code built into the chemical translation system that converts the seemingly random sequence of the DNA bases into usable information for creation of all the properties of the cell.

Chemical reactions, including synthetic biochemical reactions and reactions that convert energy from sunlight or chemical bonds into useful work for the cell, are all reducible to blind chemical principles. The law of mass action should be considered the underlying principle of most of cellular biochemistry. This is not to say that cellular biochemistry is simple—far from it. The control processes and interactions between metabolic cycles are orders of magnitude more complex than any human-engineered system. But there is no denying their reducibility to simple chemistry.

However, when we speak of the genotype-to-phenotype conversion system (as I refer to the DNA-directed protein synthesis process), we have left the world of organic chemistry behind. Of course, the detailed mechanisms of each enzymatic reaction still follow chemical rules. But the underlying feature of this system is not based on chemistry but on purpose. The existence of a genetic code is the very embodiment of inherent teleology. The code exists as a means to an end, and the end informs the code. The genetic code and the cellular machinery of protein synthesis are inherently purpose driven, which is manifested by the technical name for this process: "translation." Any translation, whether it is from one language to another, or from an obscure code to a meaningful statement, or from an observation to a conclusion, is inherently teleological. Translations do not occur spontaneously, accidentally, or by random chance. The translator has a purpose: namely, to convert some information into something else.

This does not imply that the biochemical cellular translation system was designed or created. That could be true or not, but it is not relevant to the issue of purpose. The proponents of intelligent design (ID) like to say that there is no similar phenomenon in nonliving nature, and they are right on that point.[42] Unlike ID, however, I do not find this to be scientific evidence of a designer. I do think that the genetic code and the translation system is the basis for the existence of teleology in all of life.

We may eventually have a good theory to explain how the translation system might have evolved through some kind of non-Darwinian selection, but regardless of how it happened, it remains a fact that the conversion of genotype information to phenotypic characteristics is a highly teleological process. There is a purpose to having such a system working in biological organisms, and that purpose is to allow for evolution. As McGrath has written, "Yet what if some kind of teleology is discerned within, not imposed upon, the biological process? What if an evolutionary teleology is an *a posteriori*, rather than an *a priori*, concept?"[43]

It does not work to argue that the mechanism for evolution evolved initially for some other purpose, and was selected for because of that alternative purpose ("exaptation"). This is a valid response to ID arguments for design that appeal to purportedly irreducibly complex features such as the eye or photosynthesis. It does not apply here because I am not arguing *for* design. The point is that however the system developed or evolved, even if teleology was not part of its evolution, teleology appears *a posteriori* with the functioning of the genotype-phenotype linkage, and is then a fixed part of all life forever. Another way to approach this idea is to think of biological inherent teleology as emerging from the adaptive interactions of the complex molecular biology surrounding the genetic code and directed protein synthesis.

What makes the translation system especially teleological, as compared to other complex cellular biochemical pathways such as photosynthesis or the metabolic Krebs cycle, or even the action of a single enzyme in the vast space of cellular chemistry? After all, no living creature, not even one of us humans, consciously communicates any willful commands to the ribosomes to make a particular protein, and there is no Aristotelian final causation of the function of the genetic code. If I am not arguing for a conscious will in the creation of this system, then where does the concept of purpose come from? Cells do not see the future and do not decide to change based on what is needed.

And that is the point. Cells do not *need* to see the future, because evolution provides a way to deal with any novel circumstances or challenges in the absence of sight, thought, will, or any form of consciousness. Evolution by natural selection is the cellular biological alternative to survival by conscious struggle. And the biochemical mechanism that allows and promotes evolution by natural selection is the linkage between an inherited genotype and an environmentally mediated selection of phenotype, a chemical linkage that is provided uniquely by the protein synthesis/translation process. Primitive protocells with metabolic cycles and catalysts such as ribozymes or polypeptides are not equipped with any such system. However it arrived, the modern universal translation system was the very first purpose-driven chemical system on the planet. It provides the nonconscious will to survive in all of terrestrial life through evolution. That is its purpose.

Mayr did not include this idea in his discussions of teleology and teleonomy in biology, and I have not seen it in other philosophical treatments of the subject. However, some writers have provided evidence consistent with the existence of an evolutionary direction beyond that resulting from purposeless accident. Simon Conway Morris's work on the ubiquitous phenomenon of evolutionary convergence could be seen as supporting the argument for inherent biological purpose.[44] Many of the findings of new evolutionary mechanisms, such as natural genetic engineering, epigenetics, and complex patterns of gene regulation,[45] are also consistent with a potentially goal-driven biological mechanism that has yet to be clearly identified or articulated. I am suggesting that the translation system is that mechanism. My purpose in proposing the idea is not to argue for its veracity, but to raise its possibility as an explanatory principle in an evolutionary process as a basis for further discussion and enquiry.

If it is indeed true that there exists a strong teleological system at the heart of every living cell, it is no wonder that evolution can proceed along its "blind" path, guided only by natural selection, and at the same time produce creatures who show every sign of being ruled by some form of purpose. As evolution produces more and more complex organisms, we arrive at the stage where purpose takes the form of a willful human decision to write an essay about teleology in evolution for the purpose of expressing ideas for others to read and think about.

If we believe (as I do) in a creator God who endowed human beings with a purpose for existence, and that we do act as purposeful agents, then humans are the final demonstration of the existence of biological purpose. For that we must thank evolution—for which, in turn, we must thank the genetic code and the system that can translate that code from the chemistry of nucleic acids to the chemistry of proteins. We might also thank God for the creation that made all this possible, but that is an option for a different discussion. What *can* be said here, however, is that if this view of the evolutionary mechanism as the ultimate source of teleology in life is correct, there is an interesting conclusion one could draw that is relevant to the theological debate on evolution. God's tool to accomplish this was none other than the natural process of Darwinian evolution, and biological evolution is actually a strong pointer to the power of God's creative majesty. ⌖

Acknowledgment

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Notes

[1]David L. Wilcox, "A Proposed Model for the Evolutionary Creation of Human Beings: From the Image of God to the Origin of Sin," *Perspectives on Science and Christian Faith* 68, no. 1 (2016): 22–43.

[2]Sy Garte, "New Ideas in Evolutionary Biology: From NDMS to EES," *Perspectives on Science and Christian Faith* 68, no. 1 (2016): 3–11.

[3]Simon Conway Morris, *Life's Solution: Inevitable Humans in a Lonely Universe* (New York: Cambridge University Press, 2004).

[4]Charles Darwin, *On the Origin of Species by Natural Selection* (London: John Murray, 1859).

[5]G. F. Joyce, "Directed Evolution of Nucleic Acid Enzymes," *Annual Review of Biochemistry* 73 (2004): 791–836.

[6]M. Antonoff, "Software by Natural Selection," *Popular Science* (1991): 70–74.

[7]W. Brian Arthur, *The Nature of Technology: What It Is and How It Evolves* (New York: Free Press, 2009).

[8]Allen W. Johnson and Timothy Earle, *The Evolution of Human Societies: From Foraging Group to Agrarian State* (Stanford, CA: Stanford University Press, 1987).

[9]Darwin, *On the Origin of Species by Natural Selection*.

[10]Arthur, *The Nature of Technology*.

[11]This was Darwin's conclusion, which displaced Lamarck's vision of phenotypic inheritance. It should be acknowledged, however, that with the emergence of epigenetics as

a potential alternative evolutionary mechanism for variation (see Garte, "New Ideas in Evolutionary Biology"), some aspects of Lamarckian thinking related to environmental influences on genomes have been given renewed consideration. However, for purposes of this discussion, I will focus on a strictly Darwinian approach to genotype and phenotype.

[12]Douglas J. Futuyma, *Evolution* (Sunderland, MA: Sinauer Associates, 2005).

[13]M. Yarus, J. J. Widmann, and R. Knight, "RNA–Amino Acid Binding: A Stereochemical Era for the Genetic Code," *Journal of Molecular Evolution* 69, no. 5 (2009): 406.

[14]Y. I. Wolf and E. V. Koonin, "On the Origin of the Translation System and the Genetic Code in the RNA World by Means of Natural Selection, Exaptation, and Subfunctionalization," *Biology Direct* 2 (2007): 14.

[15]Ibid.

[16]Ibid.

[17]S. D. Copley, E. Smith, and H. J. Morowitz, "A Mechanism for the Association of Amino Acids with Their Codons and the Origin of the Genetic Code," *Proceedings of the National Academy of Sciences of the USA* 102, no. 12 (2005): 4442–47.

[18]Joyce, "Directed Evolution of Nucleic Acid Enzymes."

[19]Stephen Jay Gould, *Full House: The Spread of Excellence from Plato to Darwin* (New York: Harmony Books, 1996).

[20]T. Shanahan, "Evolutionary Progress from Darwin to Dawkins," *Endeavour* 23 (1999): 171–74.

[21]Conor Cunningham, *Darwin's Pious Idea: Why the Ultra-Darwinists and Creationists Both Get It Wrong* (Grand Rapids, MI: Eerdmans, 2010).

[22]Richard Dawkins, *The Blind Watchmaker* (New York: W.W. Norton, 1986).

[23]Ted Peters and Martinez Hewlett, *Evolution from Creation to New Creation: Conflict, Conversation, and Convergence* (Nashville, TN: Abingdon Press, 2003).

[24]R. A. Fisher, *The Genetical Theory of Natural Selection* (Oxford, UK: Clarendon Press, 1930).

[25]S. E. Luria and M. Delbrück, "Mutations of Bacteria from Virus Sensitivity to Virus Resistance," *Genetics* 28 (1943): 491–511.

[26]Jacques Monod, *Chance and Necessity* (New York: Knopf, 1971).

[27]Daniel C. Dennett, *Darwin's Dangerous Idea* (New York: Simon & Schuster, 1995).

[28]Terry M. Gray, "Biochemistry and Evolution," chap. 12 in *Perspectives on an Evolving Creation,* ed. Keith B. Miller (Grand Rapids, MI: Eerdmans, 2003), 256.

[29]Ernst Mayr, "A teleonomic process or behavior is one which owes its goal-directedness to the operation of a program," in Mayr, *Toward a New Philosophy of Biology: Observations of an Evolutionist* (Cambridge, MA: Harvard University Press, 1988), 45.

[30]Ibid.

[31]Alister McGrath, "The Ideological Uses of Evolutionary Biology in Recent Atheist Apologetics," chap. 13 in *Biology and Ideology from Descartes to Dawkins*, ed. Denis R. Alexander and Ronald L. Numbers (Chicago, IL: University of Chicago Press, 2010), 339.

[32]Daniel C. Dennett, *Intuition Pumps and Other Tools for Thinking* (New York: W.W. Norton, 2013).

[33]David Hull, *Philosophy of Biological Science*, Foundations of Philosophy Series (Englewood Cliffs, NJ: Prentice-Hall, 1973).

[34]Quoted in Ernst Mayr, *Evolution and the Diversity of Life – Selected Essays* (Cambridge, MA: Belknap Press, 1976), 392.

[35]Dennett, *Darwin's Dangerous Idea*; and Dennett, *Intuition Pumps and other Tools for Thinking.*

[36]F. L. Sousa, T. Thiergart, G. Landan, S. Nelson-Sathi, I. A. Pereira, J. F. Allen, N. Lane, and W. F. Martin, "Early Bioenergetic Evolution," *Philosophical Transactions of the Royal Society B: Biological Sciences* 368, no. 1622 (2013): 20130088.

[37]Francisco J. Ayala, "Teleological Explanations in Evolutionary Biology," *Philosophy of Science* 37, no. 1 (1970): 1–15, 4.

[38]J. L. England, "Statistical Physics of Self-replication," *Journal of Chemical Physics* 139 (2013): 121923.

[39]H. Morowitz and E. Smith, "Energy Flow and the Organization of Life," *Complexity* 13 (2007): 51–59; and Nick Lane, *The Vital Question: Energy, Evolution, and the Origins of Complex Life* (New York: W.W. Norton, 2015).

[40]Lane, *The Vital Question.*

[41]Committee on the Limits of Organic Life in Planetary Systems, Committee on the Origins and Evolution of Life, National Research Council, *The Limits of Organic Life in Planetary Systems* (Washington, DC: The National Academies Press, 2007), 7.

[42]Stephen C. Meyer, *Signature in the Cell: DNA and the Evidence for Intelligent Design* (New York: HarperOne, 2009).

[43]Alister McGrath, *Darwinism and the Divine: Evolutionary Thought and Natural Theology* (Oxford, UK: Wiley-Blackwell, 2011), 190.

[44]Conway Morris, *Life's Solution.*

[45]Reviewed in Garte, "New Ideas in Evolutionary Biology."

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Biology

THE SOCIETY OF GENES by Itai Yanai and Martin Lercher. Cambridge, MA: Harvard University Press, 2016. x + 282 pages. Hardcover; $27.95. ISBN: 978-0674425026.

I begin with a confession (a good Christian thing to do): I am neither a geneticist nor an expert on genes, so I am not qualified to comment on some of this book's more technical aspects. However, as the authors state, they "wrote this book for a general audience, assuming no background in biology on the part of the reader" (p. 3). That said, while most aspects of the presentation are straightforward, at various points a willingness to delve into some of the more technical language of genetics (such as FOXP2, SOX9, BRCA1, SINE, LINE1, Alus, MIR) is required. General readers may be familiar with some of these terms, such as BRCA1 and BRCA2 (BReast CAncer genes 1 and 2), but are unlikely to be familiar with all, especially those whose designations are less obvious.

Yanai and Lercher state that they were motivated to write this book in the spirit of Richard Dawkins's book *The Selfish Gene*, published forty years ago, which they admire and describe as "essentially correct." So why write another book on genes? Genetics has moved on a long way since Dawkins wrote *The Selfish Gene*, so that much that was unknown then is now known. In particular, the authors focus on what has been discovered about how genes interact and the results of their interactions, a fascinating area of research. For this reason, they choose the metaphor of "the society of genes," genes collaborating and competing along the lines of the economic model proposed by Adam Smith in the eighteenth century. In Smith's model, selfish (self-interested) individuals compete and collaborate. Here, selfish genes compete and collaborate in a society of genes to their own benefit; this is an extension of Dawkins's selfish gene metaphor.

Yanai and Lercher state that "the genome … is best seen as a conglomerate of selfish genes, held together by an intricate network of cooperation" (p. x). Despite their disclaimer that "[a]nthropomorphising provides a convenient shorthand … we need to remember the full description behind the shorthand," I am not convinced that this metaphor, as with Dawkins's original metaphor, is helpful (p. 38). Genes are not active agents in the sense that human beings are in Smith's economic model. When the authors state that "each allele 'works' toward its own advantage when cooperating with its peers, exemplifying Adam Smith's hypothesis that self-interest, if channelled appropriately, maximises the common good," I think they are in danger of being misled by their own metaphor (p. 46). If organisms are "survival machines" for genes (to use Dawkins's terminology), then which common good are the genes maximizing? Not necessarily that of the organism, or even that of the so-called community of genes. For example, cancer genes will kill the organism and so destroy themselves and their fellow genes without exhibiting the slightest qualm. Yanai and Lercher's use of Adam Smith's economic model as an analogy for how genes work seems problematic. In the case of cancer genes, the analogy of a suicide bomber seems much more appropriate.

The flavor of the book can be obtained by considering a selection of topics from various chapters. Chapter 1 is a clear description of the genetics of cancer. This is the springboard for chapter 2, which examines "how your enemies define you." This chapter begins with an explanation of how bacteria incorporate information into their own genome from viruses that are attacking them, thus becoming better able to defend themselves from similar attacks in the future. While this works well for single cell bacteria, the authors point out that it is not a technique that will work for a more complex organism such as a human being. Instead, human genes allow us to manufacture antibodies to deal with intruders in our body (the authors then describe the genetics of this process).

The next chapter explores the genetics of sex. The authors say that the point of sex is that it allows the members of the society of genes to continually form new alliances and to work together more efficiently in the long run (p. 77), although what "more efficiently" means in this context is unclear. Through sexual recombination, harmful mutations can be left behind and helpful ones consolidated into the genome. An interesting conclusion is that if a man wants to reduce the mutational load passed on to the next generation, he should have children while he is young, when few mutations have accumulated in his sperm.

Chapter 4 examines the question: why does the small 0.1% difference in the genome of two individuals lead to such large differences among humans? Here, the authors seem to stray into dangerous territory, suggesting that "a small number of selfish genes (or even selfish ideas) are enough to underpin racist behavior" (p. 126).

The issue of how some genes manage and regulate other genes, turning them on or off, is described in chapter 7. This regulation allows for the develop-

ment of a wide range of organismal characteristics (phenotypes) from the same set of genes. Chapter 8 describes gene duplication and horizontal gene transfer, whereby genomes can be enriched and enlarged. For example, horizontal gene transfer between bacteria has been shown to account for the spread of resistance to drug treatments. Chapter 9 explores the evolution of eukaryotic cells (ones with a nucleus, such as those in the human body) as a merger of an archaebacterium and a eubacterium.

The final chapter describes genetic "freeloaders," genes that seem to serve no useful purpose except to ensure their own survival. Occasionally these genes do take up a new function (exaptation in Stephen J. Gould's terminology). In the human genome, the freeloaders hugely outnumber useful genes. Yanai and Lercher link this to the beginning of life on Earth around hydrothermal vents at the bottom of the ocean, where RNA freeloaders could have been abundant.

The book concludes with a paraphrase: "it is the society of genes that has brought us this far, but it is our humanity that must now bring us home." I do not share Yanai and Lercher's faith in humanity and prefer the original: "'Tis grace hath brought me safe thus far, and grace will lead me home" (from the hymn "Amazing Grace"). God's grace is a surer foundation for humanity's future than a purported society of selfish genes.

Overall, the book is a good introduction to modern genetics from a Dawkins-like perspective. A key message of the book is that many aspects of human biology are controlled by a number of genes acting together, rather than by a single gene. This exposes the lie of popular misconceptions such as our having a "god gene," a "gay gene," or an "alcoholism gene." Yanai and Lercher see their book as Darwin saw his *On the Origin of Species*, as "one long argument" (p. 258).

In the tradition of one long argument, they conclude that "this book exhibits the explanatory power that comes from viewing the genetic makeup of a species as a society of genes" (p. 258). I would dispute that conclusion, not only because their argument does not seem to be sustained chapter by chapter, but also because I find the metaphor itself to be questionable.

Nevertheless, this is a generally readable book, giving an updated view of developments in genetics since Dawkins wrote his popularizing book on the same topic. The book's major limitation is its gene-centric view of genetics. Other perspectives exist, such as the systems biology approach of Denis Noble (a colleague of Dawkins at Oxford), as exemplified in his book *The Music of Life: Biology beyond Genes.* Likewise, Jablonka & Lamb's book *Evolution in Four Dimensions: Genetic, Epigenetic, Behavioral and Symbolic Variation in the History of Life* provides a broader perspective. That Yanai and Lercher do not go beyond their gene-centric view might be due to a space constraint, but it might also be due to the constraint of their choice of metaphor.

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Mathematics

REDEEMING MATHEMATICS: A God-Centered Approach by Vern S. Poythress. Wheaton, IL: Crossway, 2015. 200 pages, bibliography, index. Paperback; $21.99. ISBN: 9781433541100.

Challenged by Kuyper's declaration that faith affects all of life, Poythress begins his book with a keen interest in exploring how faith applies to mathematics. There are other books on the subject, but in this short book, Vern Poythress adds his own view to the mix. He introduces some of the theological and philosophical work of the Reformed theologian John M. Frame, for example, *The Doctrine of the Knowledge of God*, and he acknowledges the influence of the Reformed philosopher Dirk Vollenhoven. He challenges the notion that mathematics is merely secular; instead, to cite one argument, arithmetic laws are "in essence personal" and imply a lawgiver. Poythress observes that the rules and order of mathematics demonstrate the biblical principle that God upholds the world. He attributes mathematics to God's law, a divine command, for the universe. Poythress tries to develop a philosophical position that steers away from both Christian Platonism and Christian empiricism.

While available in hardcover, *Redeeming Mathematics* is one of 20 free ebooks that Poythress has written. The list includes *Chance and the Sovereignty of God, Logic, Redeeming Science, Redeeming Sociology,* and *Symphonic Theology*. Many of his books share a variation of the subtitle "A God-Centered Approach" with the book under review. In this mathematics edition, Poythress leans heavily on his other work, such as *Redeeming Science*. In fact, some paragraphs are borrowed verbatim, and some of these words also appeared in his 2003 article "Why Scientists Must Believe in God: Divine Attributes of Scientific Law." In other places he encourages the reader to consult his other works to get the full details of his argument. In the end, I would have preferred that the book

were self-contained and did not lean so much on his other works. His brief supplemental chapter on other resources could have been more robust and included, for example, brief commentary on the edited books by Bradley and Howell, *Mathematics in a Postmodern Age: A Christian Perspective* and *Mathematics through the Eyes of Faith*, or Byl's *The Divine Challenge: On Matter, Mind, Math and Meaning*, which are listed in the bibliography.

This book is not specifically written as an apologetic argument; rather, it is meant to help Christians consider Kuyper's clarion call in the context of mathematics. In a world that views mathematics as purely secular, Poythress aims to recover "a robust doctrine of God's involvement in daily caring for his world." Poythress leans heavily on the Reformed Christian apologist Cornelius Van Til, often via the work of John Frame. In particular, he draws on the concept of the Trinity to bolster his ontology of mathematics and he uses Van Til's analogical approach with an oft-repeated refrain that we are "thinking God's thoughts after him."

In chapter 1, Poythress ties arithmetic statements such as 2+2=4 to some attributes of God, such as being immutable, omnipresent, and omnipotent. He develops the idea that arithmetical rules are part of the Law of God for creation, part of God's Word. He then describes the personal character of Law, the goodness of Law, the beauty of Law, the righteousness of Law, and the Trinitarian nature of Law, declaring that arithmetic participates in all these attributes. Through these, Poythress recognizes a nonsecular approach to mathematics. He observes that "people working with mathematics rely on God's Word in order to carry out their work" and exposes the nonbiblical notion that God acts in creation, but only in supernatural ways via miracles. After all, as noted in Psalm 104, God "causes the grass to grow." Poythress notes that laws reflect God's character, but in my mind, he takes the analogy too far. Instead of simply saying that mathematics captures part of God's regular working in the world, he equates the laws directly with part of his character.

In chapter 2, Poythress briefly addresses the philosophical problem of the one and the many, tying it to one's understanding of mathematics. He uses the concept of the Trinity to make sense of the unity and diversity of the created world, describing how the expression of unity and diversity in number concepts reflects God's character.

In chapter 3, he describes the limitations of a materialist worldview to answer the philosophical problem of the one and the many. He argues that materialism does not adequately explain the origins of mathematics. In chapter 4, Poythress reflects on the nature of numbers. He attributes mathematical equations to God's speech, associating them with the divine characteristics of omnipresence, eternality, and omnipotence. In this chapter, he develops an analogical tie to the Trinity using Frame's three perspectives: normative, situational, and existential. He develops these perspectives to further connect arithmetic with God's character.

In chapter 5, Poythress describes Frame's square diagram for understanding transcendence and immanence in Christian perspective. He connects the square to different interpretations of arithmetic statements such as 2+2=4. In chapter 6, Poythress covers the concepts of necessity and contingency with respect to God and mathematics, elaborating on the relevance of Frame's square for transcendence and immanence. He notes that numbers exist eternally, "not as Platonic abstractions, but as an aspect of God's knowledge." In a later chapter, he argues, based on the character of God, that numbers could be no different in any alternate universe.

In chapters 7–10, Poythress explores addition, the idea of succession, and multiplication. He develops curious links to the Tabernacle, the Trinity, and breeding animals. For example, Poythress argues that since God uses numbers to describe proportions for the earthly temple, this illustrates that numbers derive from God, instead of allowing for the fact that God may be communicating a broader principle using human-accessible terms. In chapters 11 and 12, he links symmetries and sets to the character of God. In chapters 13–16, Poythress links fractions, irrationals, and imaginary numbers to God via his three perspectives. In chapters 17–19, he touches on infinity, geometry, and higher mathematics before ending with a very brief conclusion. In the appendices, Poythress helpfully describes other philosophies of mathematics as well as other Christian approaches to the philosophy of mathematics. He describes Christian Platonism as well as a Christianized empiricism, giving critiques from his perspective.

There are a few places where Poythress could have taken more care in his writing. Some chapters start with stunted introductory paragraphs that deserve to be developed. He makes a speculative conjecture about the etymological roots of the word "irrational," tying it to later decimal representations instead of to the ambiguity of the Greek word for ratio within the context of the Greek worldview. He incorrectly states that imaginary numbers were introduced historically to be solutions to equations, rather than a means to a real solution. When reflecting on unexpected

applications of imaginary numbers, he provides the unsatisfactory statements that "God in his wisdom made it so," and that such numbers "are known by God," making them "real." Finally, on occasion in an argument, he has inserted the word "clearly" unnecessarily. For example, he brushes off a common inference as "clearly invalid" (p. 20); the adverb is either redundant or dismissive.

But these issues are minor and perhaps picky concerns. The bigger concern is with the overall argument itself. While I appreciate his anti-reductionist approach, allowing for the complexity and diversity of the created world, I do not find the analogical approach particularly convincing. In my opinion, it is applied too literally. And his oft-repeated refrain of thinking God's thoughts muddles the distinction between God's character and the specific way God upholds the creation, not to mention the particular ways that humans observe God's handiwork. In the end, despite his intention, I find it hard to distinguish his position significantly from a Christianized Platonist approach. Nevertheless, Poythress provides food for thought for those exploring the relationship of faith and mathematics.

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WEAPONS OF MATH DESTRUCTION: How Big Data Increases Inequality and Threatens Democracy by Cathy O'Neil. New York: Crown, 2016. 218 pages, notes, index. Hardcover; $26.00. ISBN: 9780553418811.

If you are looking for a dispassionate analysis of ethical issues in the use of big data, this book is not it. "Weapons of math destruction" (WMDs) are algorithms whose analyses of human data are used to make decisions that affect people's lives in nefarious ways. O'Neil's last chapter opens with the words, "As you know by now, I am outraged by all sorts of WMDs." So why does O'Neil call some algorithms weapons of math destruction? And why is she so outraged by them?

Here is one of her examples. In 2009, Michelle Rhee was chancellor of Washington, DC's public schools. She was appointed by a new mayor, Adrian Fenty, who wanted to improve the quality of DC's schools. His plan was straightforward: "Evaluate the teachers. Get rid of the worst ones, and place the best ones where they can do the most good." Rhee implemented a teacher assessment tool called IMPACT developed by a consultancy, Mathematics Policy Research, based in Princeton, NJ. It was a value-added model, measuring the educational progress of students and calculating how much of that could be attributed to the teacher. In 2011, based on its results, 206 teachers were fired, an action which O'Neil regards as unjust. The algorithm was very complex—it took into account not only test scores but other factors as well, such as the presence or absence of learning disabilities and socio-economic background—but the algorithm was not available for review or critique. There were neither independent means to assess the accuracy or effectiveness of the tool nor any means of feedback by which it could be improved. The resulting assessment was based on a small sample, only the 25 or so students in a teacher's class. And it was vulnerable to cheating. In the case of one fifth grade teacher who was fired, subsequent review of her students' fourth grade assessment tests suggested that they might have been altered to make the fourth grade teachers look better.

So what makes algorithms WMDs? O'Neil focuses on several characteristics: they define their own reality and use it to justify their results; the underlying models are often opaque or even invisible to those affected by them; they tend to punish the poor; they may use sloppy statistics and biased models that create their own feedback loops; and they are unfair in that they may damage or destroy lives.

Here are two more examples: (1) Crime prediction software such as PredPol and CompStat, and (2) E-scores. These programs illustrate the feedback loop issue: more patrolling in a neighborhood creates more data fingering that neighborhood. They also illustrate the uneven treatment of the poor, as much of the data is for "nuisance crimes" included as relevant because of a purported link between antisocial behavior and crime; yet, the data exclude "white collar" crimes. Thus, the assessments contribute to a system of discrimination against the poor. In the second example, E-scores are scores rapidly computed online to evaluate potential customers. They take into account information such as web browsing history, purchasing patterns, and location of the visitor's computer. Thus, for instance, at call centers e-scores are used to identify potentially more profitable prospects and funnel them to a human operator. But again there is a nasty feedback loop: people from poor neighborhoods get lower scores, and hence less personal attention, less credit, and higher interest rates. Predatory advertising is also generated through these scores.

Some further examples O'Neil addresses include recidivism models, risk models such as those used by hedge funds, the *US News* college rankings, personality tests sometimes in job application processes, automated resume reviews, use of behavioral data

in advertising, the algorithms used by Facebook to decide who gets to see one's posts, and more. She writes, "I am worried about the separation between technical models and real people, and about the moral repercussions of that separation (p. 48)." Hence, she identifies several sources of the problems that turn algorithms into WMDs. Models may encode human prejudice, misunderstanding, and bias into the software systems. Oftentimes, problems arise from the choice of goals, for example, desire for profit may far outweigh fairness. Many use proxies that are poor substitutes for the data one really wants but cannot measure directly. Opacity is often defended as "intellectual property." Software often does not get feedback on its performance.

O'Neil never plays the role of the neutral observer of algorithms for analyzing big data sets. Her passion for her message is explicit on every page (which for me, made reading her book somewhat exhausting). She does not pay much attention to the benefits these algorithms can provide. To her credit, however, she goes beyond analyzing the problems to propose and discuss solutions, including the use of some type of Hippocratic Oath for modelers, reevaluating metrics of success, identifying and eliminating unfair systems, incorporating positive feedback loops into models, requiring the auditing of algorithms, adapting and enforcing current laws, and requiring that models that have a significant impact on people's lives (e.g., those that assess credit ratings and e-scores) be open to the public and available.

The book is a must-read, I believe, for statisticians, operations researchers, managers of information systems, and anyone studying these fields. Relevant chapters should also be read by people working in or studying human resources, finance, educational assessment, criminal justice, and insurance. The book will also appeal to anyone interested in the impact of technology on culture.

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Origins

SHADOW OF OZ: Theistic Evolution and the Absent God by Wayne D. Rossiter. Eugene, OR: Pickwick Publications, 2015. Paperback; $24.00. ISBN: 9781498220729.

This is an anti-evolutionary book that stands basically within the tradition of the modern intelligent design movement (e.g., Stephen Meyer, Discovery Institute). In particular, Wayne D. Rossiter attempts to argue that theistic evolution is not only scientifically vacuous, but more seriously it falls far short theologically. From his perspective, "there is no distinguishable difference between theistic evolutionism and atheism when it comes to our physical reality. Neither includes a God that is in any way *detectable* in his creation" (p. 25, my italics).

The notion of so-called "divine detectability" is a long-standing theme of the ID movement. To be more precise, Rossiter and ID theorists confidently proclaim that there are places in nature where God has miraculously intervened during the past. Rossiter openly states that he views God "as an active participant in his creation" and "an evidenced player in the workings of the universe" (p. 17). In appealing to scripture, Rossiter asserts, "In the Bible, God is clearly in the business of doing things that we would see in terms of manipulating physical laws and material quantities" (p. 115).

Of course, Rossiter's approach is another God-of-the-gaps view of divine action, and the history of science has repeatedly shown the failure of such attempts. The purported gaps in nature are, in fact, gaps in the scientific knowledge of those defending these anti-scientific and anti-evolutionary views of nature.

In his criticism of theistic evolution, Rossiter attempts to gather scientific arguments against biological evolution, but it is quite obvious that the foundation of his God-of-the-gaps thesis rests firmly on a concordist hermeneutic, not science. For example, he argues,

> The word "kind" appears twelve times in the Genesis 1 account (NIV), and the phrase, "according to their kind"—plural—occurs eight times. Old Testament Jewish authors used such repetition for emphasis of important ideas. It was clearly important to indicate God *directly* made numerous kinds, and not just one. (p. 50, my italics)

However, Rossiter completely fails to appreciate that the category of "kinds" in Genesis 1 is an ancient taxonomical notion reflecting the common belief that living organisms were immutable and created *de novo*. To be more specific, this notion is rooted in an ancient phenomenological perspective. Evidence that Rossiter is completely unaware of the ancient scientific context of scripture appears when he states, "There is nothing in the Bible that teaches that we must see the Earth as the spatial center of creation, nor that the universe should be smaller than it is" (p. 59). It is well established within evangelical biblical scholarship that scripture features a three-tier universe (e.g., John Walton, Paul Seely, Peter Enns, Kenton Sparks, Kyle Greenwood). Christian astronomers today never appeal to this ancient cosmology in their daily work, nor should Christian biologists,

such as Rossiter (he is a parasitologist), employ the ancient biology in the Bible to understand the origin of life.

To employ a term used by Rossiter, there are some statements in his book that are "patently false" (p. 17). He asserts in one place, "theistic evolutionists get their pantheism honest" (p. 20); and in another, "the basic view of theistic evolution is that of process theism" (p. 69). It is evident that Rossiter is completely unaware of the distinction between pantheism and panentheism.

In another patently false assertion, Rossiter asks, "What exactly does Jesus do in the theology of theistic evolution? Other than the satisfaction of knowing that the universe is created, their worldview seems to offer nothing different than that of secular atheism" (p. 85). Would Christian evolutionists of the American Scientific Affiliation or the BioLogos Foundation see their views as nothing but a form of secular atheism?

This is a deeply flawed book at many levels. But its greatest problem is that it conflates evolutionists of a wide range of theological/philosophical views into one category—theistic evolution. In this way, it collapses into one undifferentiated smudge conservative evangelical Christians (Francis Collins) with panentheists (John Haught), liberal Christians (Karl Giberson), and naturalists (Howard Van Till). I suspect that most evangelical Christians who accept evolution would be troubled (and maybe even insulted) with this conflation, as I was.

I do not recommend this book.

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Philosophy & Theology

DIGNITY AND DESTINY: Humanity in the Image of God by John F. Kilner. Grand Rapids, MI: Eerdmans, 2015. 402 pages, including bibliography and indices. Paperback; $35.00. ISBN: 9780802867643.

What does it mean to say that human beings are created in God's image? This question has fascinated and puzzled biblical commentators and theologians for centuries. It has been of interest recently in pop culture as well, for instance, as one of the running themes of Darren Aronofsky's 2014 film *Noah*. The film juxtaposes two contested interpretations of the image of God, contrasting Noah's family on the one hand, whom God had charged with caring for the earth and its inhabitants, with the villainous Tubalcain on the other, who believes that bearing God's image entitles him to seize, dominate, consume, and control.

Aronofsky's film vividly portrays the problem that John F. Kilner, Forman Chair of Christian Ethics and Theology at Trinity Evangelical Divinity School, seeks to address in his important new book, *Dignity and Destiny: Humanity in the Image of God*. Specifically, Kilner addresses the issue that has plagued numerous interpreters of the *imago Dei* through the ages: "Rather than people being in the image of God, God is remade in the image of people" (p. 50). This happens when interpreters define the image in terms of attributes that people presently possess. The reasoning seems natural to many: we humans are uniquely made in God's image, so we can unpack that image by looking at attributes uniquely characterizing human beings, and even come to a better understanding of God in the process. But this, says Kilner, reverses what the biblical authors understand the image to be and how they employ it throughout scripture.

The book is divided into three major parts. Part I addresses "The Human and Divine Context" and sets the stage by discussing the importance of the image of God, why interpreting it correctly is so crucial (and incorrectly so harmful), and the basic meaning of the term in the Bible. Part II is entitled "Human Dignity" and explores the image of God in light of its connection to the inalienable, God-given dignity that all human beings have by God's decree. Part III, "Human Destiny," explores the renewal and consummation of the image of God in human beings, through their union with and transformation in Christ, who is the definitive and ultimate Image of God.

The book is comprehensive in gathering the scriptural and historical texts that directly reference the image of God. Four major themes are prominent. First, Kilner exposes the tendency of interpreters to view the image of God in terms of how people are presently like God, especially in terms of human attributes. (This charge is repeated many times, to the point of being repetitive.) At best, interpreters with this tendency are well intended but still misconstrue the biblical data while pursuing their own theological aims. At worst, this tendency leads to abuses of image language with horrific consequences, in support of discrimination (of the disabled, the mentally impaired, women, etc.), racism, colonialism, slavery, and genocide (see pp. 18–37). Such abuses ensue when interpreters first equate the image of God with certain human attributes, and then notice that these are diminished or absent in some people, leading to

the conclusion that the latter are not in God's image, or are so to a lesser degree than others, and thus are less worthy of dignity and rights.

Second, Kilner points out that the true, definitive, and ultimate image of God is Jesus Christ alone. Christ *IS* the image of God in terms of being an exact image-imprint of God. Humans, similarly but not exactly, are created "in" or "according to" the image of God, which is to say that they are created from the mold of the prototype (so to speak), Jesus Christ. Creation in the image of Christ implies both a status (due to a special connection with God) and a goal for humanity: "Christ's connection with God is one essential aspect of what it means for Christ to be God's image. Yet Christ's reflection of God demonstrates what God intends for humanity to be as well" (p. 72). Christ is the prototype (p. 80) and the standard (pp. 143, 145); he is the second Adam (p. 74), being both the exact imprint of God and yet also (according to Phil. 2:6–8) formed in the likeness of human beings (pp. 69–73). Since Jesus Christ is the image of God, Kilner stresses that it is improper to say that the image of God is ever lost, diminished, damaged, or destroyed. I return to and reflect critically on this point below.

Third, Kilner everywhere unpacks the basic meaning of the image of God in terms of a twofold definition: the image refers to (a) a special *connection* with God (a given status) that entails human dignity and (b) an intended *reflection* (a destiny or goal, intended, not necessarily actualized presently) that human beings are to be and become like Christ. As Kilner puts it, "It [the image] assures human dignity and sets the stage for human destiny" (p. 229). Kilner gives priority and prominence in the book to the first part of the definition (a). He likens the image to the doctrine of justification; as the latter concerns an objective reality (God's declaration that we are in the right), so the image of God is located objectively and, in a sense, simply declared and given. I wonder, however, if this is truly an apt analogy? Justification captures the first aspect of the image well (connection, status), but it fails to do justice to the second aspect (reflection, goal, task). Perhaps "salvation," more broadly conceived, provides a better analogy. Salvation has both objective and subjective components; it concerns both a given status (justification) and a call to participate by the Spirit in pursuing a goal or destiny (transformation into the image of Christ).

Fourth, the image of God is not lost or damaged in any way due to human sin and rebellion. Kilner makes this strong claim in a number of places in the book (e.g., pp. 93, 139, 141–42, 216). While it is true to say that *people* become corrupted, distorted, damaged, diminished, and lost because of sin, Kilner argues that such cannot be said of God's image. Having surveyed all of the biblical texts that employ image-of-God language, he points out that the Bible never attributes distortion or diminishment to God's image, though it does attribute such to human persons. Rather, sin covers much of the evidence that human beings are made in God's image; it does not destroy that basic connection of all human beings to God.

Kilner's book exhibits several strengths. It offers a fresh exposition of the relevant biblical passages, in conversation with both contemporary biblical scholarship and with commentators and theologians of the past. It puts forth what I judge to be an important corrective to abuses of the term: insofar as the image of God refers to a connection with God and a status of having a God-given, inalienable dignity, we should avoid saying that God's image is ever lost, damaged, or destroyed. On the other hand, I think there needs to be an acknowledgment that insofar as the image refers to a calling and a destiny to be like God, with respect to our character and our vocation as God's representatives and stewards, the conclusion that the image of God can be diminished, and often is, remains sound.

Another strength is the recognition of development and destiny implied by the image of God. Our intended destiny as human beings involves much more than just a return to Eden. Something new, always intended by God, is taking place. The Incarnation, therefore, was not a secondary plan or new initiative on God's part in response to human sin, but necessary to the fulfillment of God's plan all along (with or without the Fall). This theme is relevant to contemporary scientific discussions about the nature, origins, and destiny of human beings and thus should be of great interest to readers of *PSCF* (the question of the historicity of Adam is never addressed, but it seems to be assumed by the author). Finally, the author's insistence that the image of God refers to human beings in their entirety (and not just to certain isolatable attributes) is important and can provide balance to lop-sided approaches to defining the image.

Some shortcomings of the book need to be mentioned as well. First, while the author cites many past and present theologians in the footnotes, there is little to no actual engagement with those theologians in the body of the text, no attempt to take the broader contexts of their writings into account (in terms of both historical context and the development of their arguments). This sometimes gives the book a "biblicist" feel. Eminent theologians through the

ages—Irenaeus, Athanasius, the Cappadocians, Cyril of Alexandria, Augustine, Anselm, Aquinas, Luther, Calvin, Owen, Wesley, Barth, Brunner, Bonhoeffer, John Paul II, and many others—all get it wrong, whereas Kilner has gone back to the Bible to finally get it right. This raises suspicion.

Second, Kilner has the tendency to equate God's image with human dignity. While dignity is a legitimate theological implication of being created in God's image, it is neither the primary sense of the term nor is it even in view in most of the relevant biblical texts. In my estimation, Kilner has allowed Genesis 9:6 (NIV), "Whoever sheds human blood, by humans shall their blood be shed; for in the image of God has God made mankind," to overdetermine his interpretation of the image of God. He criticizes those that interpret the image in terms of rulership and representation (strangely and mistakenly referring to rulership as an "attribute," rather than a "calling" or "vocation"), because "rulership is not consistently present in other biblical passages about God's image" (p. 45). But this reveals three errors on Kilner's part: (1) one cannot simply determine the meaning of a word by reducing it to a lowest common denominator, such that it can only mean what it is associated with in every occurrence; (2) applying the same faulty criterion renders Kilner's own association of the image with dignity problematic, because this meaning is not itself present in every occurrence of image language in the Bible; and (3) Kilner does not sufficiently allow the historical (Ancient Near East) context and narrative flow of Genesis 1 to define the meaning of the image of God. This goes against the grain of Old Testament scholarship on Genesis 1 (e.g., Brueggemann, Clines, Longman, Merrill, Middleton, von Rad, Waltke, Walton) without adequate warrant. Kilner seems to read Genesis 9:6 into Genesis 1, again allowing it to overdetermine the meaning of the image.

This leads to a third problem in the book, which is that Kilner overstates the claim that the image of God is never damaged, diminished, corrupted, or lost. With respect to image as a status linked with basic human dignity (based on Gen. 9:6), there is some justification for the claim. But with respect to the image being a reflection, a goal, and a destiny, his assertion is too simplistic and becomes misleading and contradictory. Kilner himself writes,

> People retain a special connection with God (though their relationship with God is badly damaged), and God still intends for people to reflect likenesses to God (though in actuality they largely fail to do so). (p. 134)

Kilner acknowledges that humans fail to reflect God's likeness but largely avoids the logical implication of this—that the image is thereby diminished in some sense—by conflating the two senses of image (as connection and/or reflection) and then arguing by equivocation.

Another way that Kilner attempts to make the claim that the image is never damaged is by pointing out that, properly speaking, Jesus Christ alone is God's image. While true in itself, Kilner draws from this observation a conclusion that does not follow. Yes, Jesus is God's image par excellence (Col. 1:15); it is precisely because of this that we are supposed to imitate Christ and grow into his likeness through our participation with/by the Spirit. We fail to do that, sometimes drastically so (e.g., think of Hitler and Stalin). How then can it be the case that the image remains uncorrupted in human beings, as Kilner claims? He evades this logical consequence by insisting that Jesus himself is the Image and Jesus is never corrupted (of course, all agree on this), but this again equivocates two senses of the image of God. Moreover, it makes his doctrine of the *imago Dei* seem almost Platonic, the Image operating like one of the forms: we are made according to the Image, in some vague sense we shadow it, and we are moving toward reflecting it fully (when we are glorified). But the Image itself [Christ] never changes; it remains totally Other. "People are in God's image—God's image is not in people" (p. 150).

Finally, Kilner nowhere defines what a human being is. Perhaps he thinks the answer is obvious and so a definition is unnecessary. But it seems to me that defining what it is to be human is at least as important as defining the *imago Dei*. One could theoretically agree with the author that the image of God is never damaged or diminished in humans but then still regard certain individuals, or whole groups of people, to be subhuman and thus exempt from image of God status (intact or not). To cite one of several examples, Kilner suggests that victims of the Nazi holocaust suffered the consequences of a distorted interpretation of the image of God (p. 311). While there may be a correlation at play here, Kilner overstates the causal connection and drastically oversimplifies the problem. At issue was not the definition of the image of God as such, but the failure to regard certain people (Jews, Gypsies, homosexuals, etc.) as fully human and thus entitled to *imago Dei* status.

Despite its shortcomings, Kilner's *Dignity and Destiny* is an important recent study of what it means to be created in/according to God's image. Widely refer-

encing biblical texts, touching on theological history, relevant to contemporary faith-science conversations about human origins and destiny, and passionately attuned to the importance of its subject matter for the oppressed and the vulnerable, it deserves a wide readership.

Reviewed by Patrick S. Franklin, Associate Professor of Theology and Ethics, Providence Seminary, Otterburne, MB R0A 1G0.

BEING HUMAN, BEING CHURCH: The Significance of Theological Anthropology for Ecclesiology by Patrick S. Franklin. Carlisle, UK: Paternoster, 2016. 325 pages. Paperback; $49.99. ISBN: 9781842278420.

The theme of this book is that a theologically adequate doctrine of the church presupposes an equally adequate doctrine of the human person. The meaning of being human has a decisive bearing on the meaning of being church. This insight alone makes an important contribution to the contemporary discussion about the nature and mission of the church, no matter which part of the ecumenical mansion happens to be one's home. Patrick Franklin's aim is to develop a holistic view of the human person that is theologically more satisfying than all the competing models he describes.

To develop an adequate theological anthropology the author draws heavily from the works of contemporary theologians who have contributed to a renewal of the doctrine of the Trinity, most notably Wolfhart Pannenberg, Jürgen Moltmann, John D. Zizioulas, Colin Gunton, Miroslav Volf, and Catherine LaCugna. Surprisingly absent from this list is the name of Robert W. Jenson, American Lutheran theologian, who has written more extensively and creatively on the Trinity than most of the others.

Franklin writes from the perspective of an evangelical theologian, affiliated with the Baptist tradition. He agrees with the charge that historically Evangelicalism has lacked a coherent ecclesiology; in this book, Franklin rises to the challenge to demonstrate that Evangelicalism has the resources within its tradition to compensate for this deficit. In doing so, he cites a number of his fellow evangelical theologians who have written books on ecclesiology from a Trinitarian perspective, in particular Stanley Grenz and Miroslav Volf. Both of these have reached considerably beyond Evangelicalism to enrich their thinking about the church. As for the author himself, he cites the works of Dietrich Bonhoeffer more often than any others. Bonhoeffer's dissertation on the church, *Sanctorum Communio*, which Karl Barth called a "theological miracle," is accorded a place of preeminent significance.

Franklin writes that evangelical ecclesiological imagination must expand and deepen. That is true not only for evangelical theologians but for all of us in different regions of the worldwide church. Our thinking about the church has been too small. What is the best strategy to expand and deepen our ecclesial imagination? Franklin gives it an injection of Bonhoeffer and others. Is that sufficient? I do not think so. What is missing is a broader ecumenical perspective that takes seriously more of the Eastern Orthodox, Roman Catholic, and Anglican theological traditions whose strong suit is and has always been ecclesiology. Granted, Pannenberg and Moltmann are both ecumenical theologians who have invested a lot of thought in doing just that. Pannenberg especially has been at the forefront of ecumenical dialogue, a leader in Faith and Order and a member of the Catholic-Lutheran Dialogue, both of which rank ecclesiology as a topic of highest importance.

Franklin's book on the nature of being human and its relation to the nature and mission of the church is a worthy gift to the ecumenical quest for a deeper and broader ecclesiology whose goal is to restore unity to a badly divided Christian world. To give one example, Franklin strongly emphasizes that the worldwide apostolic mission of the gospel of Jesus Christ is part of the essence of the church, a theme not always front and center in the majority of books on ecclesiology that are preoccupied with institutional questions of order. Readers would do well to receive with gratitude the insights Franklin's book offers their own search for a richer understanding of the church.

Reviewed by Carl E. Braaten, Professor Emeritus of Systematic Theology of the Lutheran School of Theology at Chicago and Founder of the Center for Catholic and Evangelical Theology.

Science & Biblical Studies

SCRIPTURE AND COSMOLOGY: Reading the Bible between the Ancient World and Modern Science by Kyle Greenwood. Downers Grove, IL: IVP Academic, 2015. 251 pages. Paperback; $24.00. ISBN: 9780830840786.

Kyle Greenwood's *Scripture and Cosmology* helpfully introduces nonspecialists to biblical cosmology in the context of the ancient world and shows how Christians in the medieval and early modern periods who were committed to biblical authority had to adapt their interpretation of scripture in the light of what they were learning from science. Following a brief introduction (chap. 1, "Scripture in Context"), *Scripture and Cosmology* is organized into three main parts.

In Part 1, "Scripture and Cosmos in Cultural Context," Greenwood takes the reader on a tour of "Ancient Near Eastern Cosmologies" (chap. 2), exhibiting how Israel's neighbors thought of the structure and nature of the cosmos. Drawing on a variety of ancient writings, carvings, and drawings to illustrate his analysis, Greenwood shows that the cosmos was consistently pictured on the model of a building. In particular, he sketches the common idea of the cosmos as tripartite, consisting of the heavens (above), the earth (as a flat land mass), and the sea (beneath and around the earth, usually thought of as a single cosmic ocean or deep).

In "Cosmology in Scripture" (chap. 3), Greenwood goes on to demonstrate how the same basic ideas show up in the Old Testament. Using a variety of biblical texts, Greenwood shows that the writers of scripture thought of the heavens as either a solid, dome-shaped structure overhead (the "firmament") or a taut tent that God stretched out (tents were more stable structures in the ancient world than we usually imagine). In either case, the heavens functioned as the roof of the world, serving to hold back the upper cosmic waters. The heavenly bodies—sun, moon, and stars—were fixed in the firmament and below it were birds and clouds, while God's throne was typically located above or upon the firmament. Greenwood thus distinguishes the "upper heavens," the realm of God and angels, from the "lower heavens," which included ordinary celestial phenomena, with the firmament in between. The heavens were supported by the distant mountains at the extremities of the earth, the roots of which went down into the subterranean waters; thus, the mountains also functioned as the foundations or pillars of the earth, which explained why it did not sink into the waters.

In chapter 4, "Cosmology and Cosmogony in Scripture," Greenwood endeavors to illustrate the pervasiveness of this understanding of the cosmos by drawing together a variety of creation texts from the Old Testament. His lucid analysis of the different creation accounts in Genesis 1 and 2 is especially helpful for anyone new to biblical studies, but his choice of other texts did not always seem intuitive (I could think of better ones), and the extreme brevity of his comments in some cases made me doubt the value of parts of this chapter. Yet Greenwood makes the important point that Genesis 1 is the only Old Testament creation account in which the idea of creation over six days is mentioned. And he wryly notes that while the Genesis flood is, indeed, worldwide (covering the known world), it is not technically "global," since the earth was not considered a globe.

While there is little new in Part 1 for biblical scholars (this is all widely agreed on), Greenwood goes on in Part 2, "Cosmology and Scripture in Historical Context," to narrate post-biblical changes in the accepted cosmology of Western culture, beginning with the shift from the ancient Near Eastern conception of a flat earth to the spherical earth introduced by the Greeks. In chapter 5, "Scripture and Aristotelian Cosmology," we find a helpful sketch of the contributions of Aristotle and Ptolemy to the development of the idea of a spherical earth at the center of the cosmos, around which revolved seven concentric spheres (seven heavens), in which the sun, moon, and five planets were embedded, with God's throne/dwelling beyond that. This new cosmology, which greatly expanded the imagined size of the cosmos, also included the Platonic idea of a corruptible sublunar realm, with everything beyond the moon being incorruptible (the circular motion of the sun, moon, and planets was thought to embody perfection).

Once this new cosmology became dominant in the church, it required some reinterpretation to harmonize it with the biblical world picture. In a fascinating account of how Augustine, Aquinas, Calvin, and Luther among others struggled to adapt the biblical picture to the new cosmology, Greenwood discusses the reinterpretation necessary for the "firmament," the waters above the firmament, the ends or corners of the earth, the "foundations" of the earth, and the nature of the underworld (Sheol/Hades)—to name just some of the ideas found in the Bible. Two examples of reinterpretation will suffice. Since the firmament could no longer be the dome in which the sun, moon, planets, and stars were embedded (they were not equidistant from the earth according to the new cosmology), it was now interpreted as the boundary of the seventh heaven, beyond which was the realm of God. The idea of a spherical earth resting on "foundations" was transformed into a metaphor for affirming that God kept the earth stable, without imagining literal pillars going down into the deep.

In chapter 6, "Scripture and Copernican Cosmology," Greenwood discusses the contributions of Copernicus, Galileo, and Kepler, whose work led to the heliocentric conception of the cosmos. In the remainder of the chapter, Greenwood focuses on the reception of Copernican cosmology by the Roman Catholic church, which was wedded to the Aristotelian view of the cosmos, and on ways in which Galileo, then later Luther and Calvin, tried to address the discrepancies between the Bible and the new cosmology. While the opposition of the Catholic church and Galileo's trial (then later inquisition)

are well known, it was instructive to read about the responses of the Protestant reformers, who had already worked at reconciling biblical cosmology with the Aristotelian view. Living so close to the rise of heliocentrism, they struggled to affirm the truth of the new cosmology and the teachings of the Bible, for example, how to affirm the nature of the sun and moon as "lights," given that the moon was not technically its own light source.

In Part 3, "Scripture and Science," Greenwood first (chap. 7, "Cosmology and the Authority of Scripture") develops Calvin's doctrine of divine accommodation to account for the disjunction between biblical cosmology, which utilizes ancient Near Eastern ideas as a vehicle for revealed truth, and our changing scientific understanding of the cosmos. Then, in chapter 8, "The Authority of Scripture and the Issue of Science," he uses the example of medicine to show the value of going beyond the "scientific" ideas assumed in the Bible, and then returns to how various Christian and Jewish theologians throughout history related the science of their day to biblical truth. He concludes with famous words from Charles Hodge and Augustine about respecting what experts in science tell us about the world instead of trying to make scripture speak authoritatively on that subject.

Since Greenwood's book is so helpful in what it accomplishes, I hesitate to raise criticisms or caveats. But a few are in order. First, Greenwood uses the term "worldview" as equivalent to cosmology, which is confusing and bypasses the immense literature on worldviews that has developed in the past half century. It would have been helpful if he had distinguished the *world picture* (German: *Weltbild*) or cosmology that the Bible assumes from its normative *worldview* (German: *Weltanschauung*), the distinctive and abiding theological vision that God was revealing precisely through this ancient world picture. The biblical writers were using an ancient cosmology to communicate a normative worldview meant to orient us to the ultimate meaning of this world.

One caveat that should be noted is that the ancient Israelites did not distinguish the upper heavens, the realm of God and the angels (pp. 85–89), from the lower heavens, the realm of birds, clouds, and celestial bodies (pp. 89–94), quite so clearly as Greenwood does (the terminology of "upper" and "lower" heavens is not actually biblical). True, Job 22:14 says that God walks on "the dome of the heavens" and God's throne is sometimes pictured as resting upon the firmament, which is sapphire/blue in color (Exod. 24:10; Ezek. 1:26). Yet Psalm 104:2–4 envisions God dwelling in the heavenly tent he has spread out, and he is portrayed as clothed in the light of the sun, with the winds and lightning as his servants—thus mixing phenomena from the so-called upper and lower heavens. This mixing is further evident in various biblical texts that identify stars with angels (Job 38:7; Judg. 5:20) and by the use of "the host of heaven" to refer variously to angels (1 Kings 22:19; Ps. 103:20–21), stars (Ps. 33:6; Isa. 40:26), or false gods (2 Kings 17:16; Isa. 24:21). In general, God is simply said to dwell "in" the heavens, which is a symbol for God's transcendence, since the sky above is generally inaccessible to us; but it is also a symbol of God's immanence, since God has chosen to dwell within the cosmos he created.

A second caveat would be that while the tripartite cosmos—heaven, earth, sea or underworld—is often in evidence in the Old Testament as Greenwood notes, Jonathan Pennington's *Heaven and Earth in the Gospel of Matthew* (Baker Academic, 2009) has decisively shown that this three-fold division is typically a function of a more fundamental bipartite conception of "heaven and earth" with the sea or the underworld as a subcategory of the earth. This is evident in the merism "heaven and earth" (Gen. 1:1 and 2:1), which signifies the entire cosmos. Thus, while Greenwood cites some New Testament texts that assume a tripartite cosmos (Phil. 2:10), others portray the cosmos as clearly bipartite (Matt. 6:10; Col. 1:16, 20; Eph. 1:10).

But perhaps my major substantial criticism would be that Part 2, "Cosmology and Scripture in Historical Context," ends too early, with the Copernican revolution. Even the chapter on modern cosmology feels unfinished; Greenwood just begins to discuss how Christians at the start of the modern period tried to relate biblical cosmology to the new scientific world picture. Minimally, this chapter needs some analysis of how "heaven" came to be understood as God's immaterial dimension (the way most Christians think of it today). This modern conception of heaven seems to have been motivated by the new ability to look at the night sky through telescopes; if God was not literally located somewhere "out there" in the cosmos (which made no literal sense), then "where" was he? To solve this conundrum, theologians were able to draw on the classical metaphysical notion of immaterial reality inherited from Neoplatonism, which was applied not just to God, but also to God's realm ("heaven"), thus generating the quite unbiblical idea that heaven is uncreated.

Also, it would have been extremely helpful if Part 2, "Cosmology and Scripture in Historical Context," had included a chapter on more-recent scientific

changes to our world picture, such as the Big Bang and a universe of billions of galaxies expanding and accelerating away from each other. Some reflection on how Christians have tried to connect this new cosmology to the Bible would be fascinating.

Finally, there were a number of proofreading or copy editing issues with the book. Thus "more temporary structure" on page 82 should actually be "more permanent structure"; here Greenwood is describing two metaphors that biblical writers used to describe the ceiling of the world: "One appealed to their nomadic past using tent imagery. The other employs the imagery of a more temporary structure." Then, at the bottom of page 163, "sun" and "earth" are reversed: Copernicus did not shift "the center of movement from the sun to the earth," but vice versa.

More confusing is that the term "hendiadys," used twice on page 86. It should be "merism," although technically a merism is a contrasting pair meant to include everything in between. Here "hendiadys" is used as a comprehensive list of items—five in one case (Ezek. 38:20) and three in the other (Zeph. 1:3).

But these are small details and do not really detract from a most helpful volume.

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Science and Religion

FAITH AND WISDOM IN SCIENCE by Tom McLeish. Oxford, UK: Oxford University Press, 2014. 304 pages. Hardcover; $32.95. ISBN: 9780198702610.

This is the best book I have read all year, and the best I would expect to read for a long time to come. It is a superbly crafted exploration of the relationship between science and faith (yes, another one of those, but stay with me a bit!) by an author deeply conversant with both topics. He is wise enough to discern the foundations on which both enterprises rest, humble enough to offer his observations without offense, and literate enough to do so in a marvelously well-written text. The book flows smoothly from one difficult topic to another, erudite but not showy, scholarly but not dense, bold but not brash.

Tom McLeish is Professor of Physics and, until recently, Pro-Vice-Chancellor for Research at Durham University in the United Kingdom. His specialty is the molecular theory of complex fluid flow, and stories from his own collaborative research find their way into the text. He is a public intellectual, drawing on his academic reputation to influence policy decisions regarding science. He is a Fellow of esteemed professional organizations, including the Royal Society. And he is also a Christian. He does not explicitly state that in this book, but his ruminations on scripture are not merely theoretical; they are also devotional. He writes of both faith and science as an insider, as one with investment and commitment to the enterprises they represent and the assumptions on which they are founded.

McLeish would have us do away with any notion that theology and science are distinct entities; he wishes to delete the "and" between those two words and substitute "of." He illustrates and initiates this agenda by proposing his own rudimentary theology of science, rooted in love.

McLeish is a story teller. He arrives eventually, in his penultimate chapter, at this theology of science by way of a series of small narratives, beginning with stories of natural philosophy, the love of wisdom in nature, which was what science was called before that word was invented in the early nineteenth century. The love of wisdom is a trait that both people of faith and people of science share, for example, Robert Brown (for whom Brownian motion is named), the thirteenth-century Bishop of Lincoln, the seventh-century Venerable Bede, and Macrina, the theologian sister of the fourth-century Cappadocian Fathers. These are fascinating and penetrating vignettes surveyed in chapter 2.

In chapter 3 he explores natural wisdom in the Old Testament, particularly in its multiple creation narratives in the Proverbs, Psalms, prophets, and, of course, Genesis. (A reader might be surprised to discover that the Jewish scriptures contain more than one, or even two, treatments of the origins of the natural world.) This culminates with a marvelous exegesis of the oldest and murkiest wisdom literature of the Jewish/Christian scriptures: the Book of Job. McLeish explores the story of Job through the lens of order and chaos in the natural world—how this is interpreted by his friends, by Job himself, and finally by the Lord speaking from a whirlwind. He then moves to the New Testament explorations of the meaning of the natural world, particularly as found in the themes of creation and reconciliation (to which he later returns).

His purpose in this highly informed biblical survey is to illustrate that the enduring questions of natural philosophy are rooted deeply in the pain and passion of human experience, and therefore they do not belong solely to the rationality of modern science. And science itself is not as rational, orderly, or methodical as its champions sometimes insist:

> Science runs far deeper, quirkier and at more fully human levels than we would think from stories of relentless discoveries, spectacular phenomena or the cool application of a fixed methodology. We know better than to swallow an inadequate narrative that portrays science as simply replacing an ancient world of myth and superstition with a modern one of fact and comprehension. Science, as we have framed it with a broader and older "love of wisdom of natural things," does indeed call on a growing illumination of nature of experiment and imagination, creating understanding where there was none before and opening up the exploration of new phenomena … But science also emerges from an ancient longing, and from an older narrative of our complex relationship with the natural world. Its primary creative grammar is the question, rather than the answer. Its primary energy is imagination rather than fact. Its primary experience is more typically trial than triumph. (p. 102)

How, then, do science and faith relate? He suggests that there have been three distinct approaches to their relationship, all of which he finds inadequate. The first is to declare them competitors in the search for ultimate explanations about the nature and meaning of the universe. This is the approach favored by the "new atheists" such as Richard Dawkins and also by religious fundamentalists. He finds that in such a "conflict" approach both parties tend to be triumphalist about their own truth claims and both tend to misrepresent the aims and assumptions of the other.

A second approach is to divide faith and science into two entirely different fields of inquiry, and then to call offside when one encroaches on the other's territory. This is the "non-overlapping magisteria" option of Stephen Jay Gould. McLeish finds this overly limiting on both sides, as science must concern itself with matters of values, for instance, and, as his biblical overview repeatedly acknowledges, faith observes and probes the behaviors of the natural world.

A third approach "attempts reconciliation by comparative methodology, while keeping the objects of enquiry distinct" (p. 169). He specifically acknowledges the work of physicist-priest John Polkinghorne here, who has explicated on numerous occasions the overlapping epistemologies and methods of science and theology. McLeish suggests, though, that this has the effect of "reducing the universal scope of both narratives" (p. 169), and thus diminishes both.

His alternative is to offer his theology of science (he suggests that we would also benefit from a science of theology), and delineates some "common threads" from both narratives, including love, manifested in a mutual commitment to the task of reconciliation. He writes,

> Science becomes, with a Christian theology, the grounded outworking of the "ministry of reconciliation" between humankind and the world. Far from being a task that threatens to derail the narrative of salvation, it actually participates within it. Science is the name we now give to the deeply human, profoundly theological task of participating in the mending of our relationship with nature. (p. 209)

McLeish concludes with a chapter on "mending our ways," intended to offer practical suggestions on how to live out the relationship between science and faith that he offers here. In a brief epilogue he suggests that the New Testament story of conversation between Jesus and a Roman centurion can inculcate and elucidate the trust required to honor the respective authority found in each of these two enterprises.

It is doubtful that many scientists would instinctively understand themselves as philosophers of wisdom, as McLeish would have them do, much less agree that reconciliation is a primary object of their work. But what if they did? How could the relationship between humans and the natural world be transformed? And what if Christians were to perceive science as a vital aspect of our very human grappling with the questions generated by both the order and chaos of the material universe? What if we were to understand science as a source of wisdom and not merely as an object of contention? These hopes are addressed repeatedly in this journal on science and the Christian faith. If nothing else, perhaps McLeish has given us an opportunity to occasionally replace the "and" in such discussions with an "in."

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THE TRUTH ABOUT SCIENCE AND RELIGION: From the Big Bang to Neuroscience by Fraser Fleming. Eugene, OR: Wipf and Stock, 2016. 221 + xvii pages, including bibliography and index. Paperback; $29.00. ISBN: 9781498223294.

The Truth about Science and Religion: From the Big Bang to Neuroscience is a literary buffet serving a bit of everything related to science and faith. Interested in a bit of cosmology, biology, history, philosophy, with a splash of theology? You have found the book for you. Fraser Fleming, a professor and Head of the Department of Chemistry at Drexel University in Philadelphia, writes in a subtle way about science and religion while treating them equally and respectfully. I waited patiently through the 221 pages for a sentence that began with "The truth about science

and religion is …," but of course this sentence never came. Instead, Fleming seems to let readers make that conclusion on their own.

The Truth about Science and Religion is based on Fleming's own personal notes and reflections that have withstood the critiques of colleagues, editors, and students in his classes. I see this book as being of particular interest to those in the latter category. Students, and seekers in general, will benefit from the broad overview and discussion of numerous topics at the intersection of faith and science. In addition, the discussion questions and the reading suggestions at the end of each chapter are excellent inclusions for a reader who may want more. This book is not written for someone who wants an in-depth discussion of faith and a particular scientific field; rather, it is for someone who wants a bit of everything. I think this book accomplishes what Fleming states in the introduction:

> This book is intended to stimulate personal reflection more than provide an intellectual exercise, furnishing knowledge for personal reflection that in turn challenges core beliefs and provokes changes in behavior. (p. xvii)

After a brief introduction, the book is divided into eight chapters and concludes with an epilogue. I appreciate the chronological organization, from explorations of the Big Bang through to the evolution of *Homo sapiens* and our pursuit of science and purpose. Chapters 1 through 4 discuss the formation of the planet and people prior to Jesus. I appreciate the mix of physics, chemistry, and biology in these chapters. However, I must point out a few biological overgeneralizations. One example is the characterization of all macromolecules as polymers (p. 39). While it is true that nucleic acids, proteins, and carbohydrates are polymers, lipids often lack similar repeating units and thus are not polymers. Another biological error is the statement that the Golgi apparatus synthesizes proteins (p. 40). While the Golgi can modify and sort proteins, ribosomes synthesize them. These small overgeneralizations are easily forgotten as the reader finds beautiful poetic sentences such as "Plants and animals whose skeletons become compressed in sandy sediment create a book whose pages are read by sequentially dating each individual layer" (p. 58).

Chapters 5 through 7 focus on Jesus and the science and religion debate that ensued throughout history. Chapter 5 stood out from the rest of the book as it told the story of salvation and divine power from a scientific standpoint with references to things such as chromosomes (p. 95), wave amplification (pp. 100–101), chaos theory (pp. 105–6), and atoms (p. 110). Chapter 6 is by far the longest chapter of the book, and tells of the complex relationship between science and religion throughout history, beginning with the Egyptians and Babylonians. It is always encouraging to read of the times when the two had, and can continue to have, a mutually beneficial interaction. The subsequent discussion focuses on the organ which gives us the intelligence to pursue such scientific endeavors, the brain. I thought that this chapter offered particularly insightful reflection on the confusing link between the brain, mind, and soul.

The last chapter (8) ends the book on an appropriate note, a discussion of the meeting and relevance of science and faith. Fleming subtly nods toward the general theme of his writing: science points out that the "universe seems endowed with a weighed beneficence" (p. 203). Fleming writes in the epilogue that he looks retrospectively at chance events, both throughout evolutionary history and in his own life, and sees God at work. He sees chance as providential. A scientist may look at the remarkable formation of the universe, macromolecules, cells, and higher cognitive beings and see nothing but chance and luck. In contrast, someone looking from both the science and faith perspectives will see God at work in those improbable and somewhat miraculous events.

Throughout *The Truth about Science and Faith*, Fleming draws interesting parallels between the microscopic and the macroscopic. Firstly, he mentions that humans are perfectly positioned to study both as we are at the approximate mean size between the universe and the atom (p. 9). Secondly, Fleming states that there are approximately the same number of stars in the Milky Way galaxy as there are cells in the human brain (p. 171). At first glance these parallels are interesting, but at second glance I realized the awe-inspiring nature of those statements. Is it by divine providence that we are at the perfect size to look both outward at the billions of stars in our galaxy and inward to the billions of cells in our brains? What a beautiful creation awaits our scientific study!

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"Upholding the Universe by His Word of Power" Hebrews 1:3