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In This Issue …

"The fear of the Lord is the beginning of Wisdom."

Psalm 111:10

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James C. Peterson

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First Understand, Then Evaluate

There is a quotation from Thomas Jefferson chiseled into the stone above a door I have entered many times at the University of Virginia. It reads, "Here we are not afraid to follow truth wherever it may lead, nor to tolerate any error so long as reason is left free to combat it." The expectation of this quote is that it is more effective to hear out a misunderstanding or false claim, and then deal with it, than it is to suppress the expression of ill-founded ideas, so that they continue without correction. I would much rather that my students state what may be mistaken, so that I can encourage them to consider how such a view needs challenging. When ideas are suppressed, they are not visible to be tested, and who gets to decide what ideas cannot be said or considered?

This journal has published carefully developed ideas that I do not find persuasive. The first word of the journal's title is, after all, Perspectives, in the plural. What is asked of peer reviewers and editors, is not whether we agree with how an essay concludes, but rather, whether it is a new, clear, informed, and important argument. Then, standing on its own, it can be evaluated by our readers as to whether they think it has made its case. If they think not, they are encouraged to write a quick and focused letter to the editor that highlights the problem, or a better article to carry on the discussion in more detail. The point is not merely to repeat what has already been said, even if more emphatically. The point is to step by step build better understanding for all. *PSCF* gladly publishes contrasting pieces as close together as possible. That is not inconsistency. That is honest conversation.

Peer review plays an important role in this process, testing ideas to see if they are aware and clear enough for wide consideration, not to exclude and silence unpopular ones. For example, claiming that one's own view is the only view of "Science" should be received with considerable skepticism. Some claims do properly carry that appellation, but far fewer than the number that make that claim. It is hard to imagine at this point how there could ever be a paradigm shift that, well actually, the sun does orbit the earth. Too much corroborating experience and evidence has built up for that description to reassert itself from the past. Not every contention needs to be aired yet again. Often a consensus develops among authors and readers that some ideas seem settled. We can build on what has become assured. Granted, someone may develop a new argument to disrupt that consensus, leading to a new consensus. That is an exciting development when it occurs, but simply being contrary does not justify a newly offered approach. Discerning which ideas call for further assessment, and which have risen to an assured level, is a goal the journal pursues, not one that it lightly assumes.

Now essential to this process of articulation and assessment is that we should make our much-needed critiques in a way that is respectful, out of love for our dialogue neighbor. The Holy Spirit will lead us to truth, and kindness is one of the aspects specifically used to describe the presence and fruit of the Holy Spirit. Some language choices obscure ideas rather than clarify them, or are so weighted with personal offense, felt or given, that it becomes difficult to hear what is actually being claimed. Thoughtful, measured, gracious language best meets our goals of seeking first to understand, and then second to evaluate. Evaluation without first listening until one understands why the writer is so persuaded, misses an opportunity to learn. Affirming a new idea without testing, leads to confusion and loss.

In conversation, then, language that challenges what one has thought, should not be equated with personal attack or violence, even if its persuasive power is uncomfortable for cherished convictions. It is a sign of maturity and strength to appreciate being shown a way out of a falsehood.

We seek at *PSCF* first to listen carefully, and then to evaluate just as thoroughly. Thank you authors, peer reviewers, editors, and readers, for bringing your best effort to hearing one another, and then working together toward better understanding and discernment. There is always more to learn. ☼

James C. Peterson
Editor-in-Chief

Erin I. Smith

Article

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Neuroscience and Self in Interdisciplinary Dialogue

Erin I. Smith

Within the framework of theological anthropology, a robust answer to the question "what is a human being?" *necessarily requires more than a detailed explication of physical, biological parts.*[1] *Yet, theological treatments should engage empirical evidence about these constituent parts to anchor models of persons around what is empirically observable.*[2] *To facilitate the necessary interdisciplinary dialogue for such a robust treatment of persons, this article provides a brief overview of select neuroscience literature on* self. *Specifically, I provide an initial introduction to measuring neural activity and the brain's default mode network (DMN), a region of the brain associated with internal, self-related thoughts dissociated from external input. Some researchers have suggested that the DMN is what makes the "self" special; rather than the self being a higher-order composite construct, it may be foundational to the brain's operations.*[3] *Although the role of the DMN in understanding self has not reached scientific consensus, a consideration of the DMN and the results of its dysfunction may stimulate interdisciplinary dialogue in at least two ways related to questions of selves. First, given the ongoing discussion about the proper interpretation of DMN data, this area may benefit from non-empirical, interdisciplinary contributions toward understanding selves. Second, the centrality of the DMN to selves suggests a healthy DMN is necessary (though not sufficient) for a healthy self. Practices for healthy DMN functioning can contribute to and be enriched by philosophical and theological perspectives about telos and Christian practice.*

Keywords: interdisciplinary, neuroscience, self, theological anthropology, default mode network, theory, scientific interpretation, *telos*, christian practice, contemplation and reflection, spiritual disciplines, multitasking

In framing his argument about the importance of habit, James K. A. Smith argues that "every approach to discipleship and Christian formation assumes an implicit model of what human beings are."[4] In fact, beliefs about who/what humans are guide all human action; different suppositions about human nature provide different guides for human activity toward some hoped-for outcome. Importantly, these beliefs do not always explicitly guide activity. In fact, operating *outside* conscious awareness may serve to make these beliefs a more significant influence as they go unquestioned, presumed a priori. Given the significance of these underlying beliefs about what *kind* of thing a person is, especially for the Christian developing toward Christ-likeness, it is of tantamount importance to leverage all relevant tools in developing accurate models of what constitutes

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a person.[5] As discrete disciplines use increasingly specialized tools to address questions around personhood, studies in theological anthropology provide an important opportunity to integrate these disparate findings, using data to anchor proposals without being restricted to only empirical observations.[6]

Thus, the goal of this article is to explore neuroscience research relevant to theological discussions about selves. I start by introducing methods of neuroscience, highlighting how the problem of neurological baseline measures may provide insight into questions of selves. Specifically, questions about the nature of selves may be informed by research on the brain's baseline, intrinsic activity in the default mode network (DMN). Some neuroscientists argue that the DMN, essential for self-related processing, points to the self as special, a kind of fundamental, brute fact of being a self.[7] Moreover, questions about how to understand the proper functioning and purpose of selves may be informed by research highlighting how brain activity directed inward appears to be inversely related to brain activity directed outward. In discussing this research, I aim to delineate empirical anchors for conversations around personhood and to suggest pathways forward. The exploration of neuroscience, here, should not be understood as a statement that understanding humans' small, constituent parts is the key to understanding the whole of the person. However, the exploration of empirical findings across multiple disciplinary views, which includes neuroscience, promotes a more robust engagement with relevant empirical proposals to inform and enrich the integrative and generative processes involved in theological anthropology.

Measuring Brain Activity

Although an extensive introduction to the many and diverse methods of neuroscience is outside the scope of this review, one of the most important and influential tools in empirical investigations into the brain is *neuroimaging* or, as it is more commonly known, brain scanning.[8] Different brain scanning technologies exist, but the most prevalent is functional magnetic resonance imaging (fMRI).[9] fMRIs offer a window into the brain's activity by measuring changes in the blood-oxygen-level dependent (BOLD) signal. Neurons, the cells that are the basic building blocks of the nervous system, need energy in the form of glucose to function. During cognitive activity, neurons are active; neural activity, and the functioning it supports, is maintained via cerebral blood flow replenishing the necessary glucose for activity.[10] It is the change in blood flow and oxygenation of the blood that the fMRI machines measure with the BOLD signal.

The most significant limitation of the inference required to interpret the BOLD signal concerns its spatiotemporal resolution.[11] Even in a 1mm spatial measure, the BOLD signal is providing a summation of the response of millions of neurons, neurons that are measured over seconds, rather than the milliseconds of the underlying neural activity the BOLD signal seeks to measure.[12] Yet, even as there are limits in these measures, fMRI is demonstrated to be trustworthy as a representation of underlying brain activity. As new technologies emerge and become more accessible, the most pressing questions will concern the specificity of theories for empirical examination, the ecological validity of these empirical methods, and the ability to interpret across technologies.[13]

Measuring changes in brain activation has provided ample evidence for two related principles of brain activity: there is localization of function *and* distributed processing. As I discuss elsewhere, the brain consists of specific localized functions, particular activities produced/supported by discrete, localized areas of the brain (e.g., the specific areas in the brain detected in an fMRI where there is a change in the measured BOLD signal). These localized functions can be understood only in the context of the distributed nature of these functions across the cortex. For example, a function like "facial recognition" involves multiple components, each processed in specific areas distributed across different brain locations.[14]

Importantly, measuring brain activity via the BOLD signal is only meaningful as a *change* of activity. Because the brain is never "off," the brain at baseline in the fMRI machine has a particular pattern of neural activity. This baseline pattern, or control measurement, is used as a benchmark to detect subsequent changes in activation (i.e., during a particular cognitive or experimental task). Brain activity measured at baseline is subtracted from brain activity measured during the experimental task with the net differences in areas with increased blood flow interpreted as signaling the location of the brain regions that undergird that task. To say that area X of the brain is active during task A, then, requires that

there is a clear indication that X is active during A at levels notably different than X's activity during comparative tasks (i.e., baseline).

Research is clear that when "task A" concerns the self, there are many different neural correlates (i.e., area Xs, area where there is brain activity different from baseline).[15] Reading this research gives two contradictory impressions. First, it gives the impression that neuroscience knows a lot about brain activity vis-à-vis the self.[16] The second impression, however, is the exact opposite. Like reading a list of ingredients on the back of a box of cereal will not be sufficient to recreate that cereal, the literature on the neural correlates of self seems to be able to say very little about the thing of interest: selves.

However, since a watershed paper by Raichle and colleagues, neuroscience has increasingly grappled with how to interpret and integrate these diffuse neural correlates into a coherent understanding of self.[17] Although there are many significant contributions within neuroscience to understanding self, I want to briefly explore how the implicit problem in fMRI measures tackled by Raichle and colleagues may also provide important insight into the person whose brain is being measured.[18] Specifically, the problem of "baseline" measurement begs the question as to whether there is a standard neural baseline by which change detected in an fMRI can be meaningfully understood or whether any baseline measure is simply a measure of another task-induced pattern of brain activation. The subsequent question is whether and how the answer to the baseline question influences what we understand about human persons. In the sections that follow, I discuss research on the brain's baseline with the goal of exploring implications of this research program for broader conversations concerning the contribution of neuroscience to the interdisciplinary questions of theological anthropology: what a person is and what a person is for.

The Brain's Baseline

The problem of a meaningful baseline of brain activity from which to compare and understand changes in neural activity (increases or decreases *from baseline*) led Raichle and colleagues to investigate the extent to which the control measurements, usually lying supine and still with eyes shut, may be significant.[19] That is, they asked whether there was a uniform, organized pattern of brain activation across people that could serve as a benchmark for an inherently meaningful (and quantifiable) baseline of activity. Their initial work, and the body of research that has followed, indicates that the brain has a *default mode network* (DMN) with a specific pattern of activation representing relaxed, non-goal-directed neural activity.[20]

Understanding any "default mode" requires first understanding the more general properties of networks. In neuroscience, networks can be understood either as *structural,* defined by anatomical similarities, connections, and the co-activation of physically connected neurons, or as *functional,* when distributed areas of the brain are temporally connected, producing cohesive, systematic, and patterned activity during a specific task.[21] Studies of the development of brain networks suggest that early in a human's lifespan, networks are organized primarily according to anatomical proximity, with the distribution of the functional networks resulting from developmental neurobiological processes and behavior.[22] What is/is not a network can be differentiated according to structural and functional connections, though these are not without methodological or theoretical influence.[23] That the brain would not be prepackaged with networks that are objectively and clearly distinguished belies the complexities inherent in the human brain, a model complex system.[24]

The observation that the baseline measure in an fMRI provides a consistent, predictable, temporally correlated pattern of activity, such as defines a functional network, reignited questions about the intrinsic activity of the brain. This interest, and the research that followed, has dramatically influenced current conceptions of brain activity and health by exploring questions about the functional and structural organization and operations of intrinsic activity.[25] Raichle et al. named this pattern of baseline activity as a *default mode* because it represents the intrinsic, internal, and coordinated (networked) activity of an awake but resting brain.[26] Activity in the DMN, then, can serve as the baseline of the brain (since "off" is not an option). Although some researchers question whether the DMN can qualify as a *network*, discussions of core brain networks typically include the DMN on the list, suggesting an overall acceptance of its status as a meaningful network of brain processes.[27] The discussions surrounding the DMN

have spurred research to advance theory and understanding in a variety of important neurological and psychological constructs, such as memory replay and narrative, including stories for how we understand ourselves.[28] Research and theorizing about the DMN has also developed potential contributions of neuroscience to interdisciplinary dialogue that hopes to understand and define persons.[29]

The DMN includes symmetrical cortical regions in the left and the right hemispheres, focused in the middle regions of the prefrontal cortex (the brain region just behind human eyebrows) and the middle and side regions of the parietal lobe (roughly the top of the skull) and the temporal lobes (roughly behind the ears).[30] Research has demonstrated activation in this network when participants are at rest, activation that is similar to that during mind wandering (task-unrelated thought), self-referential mental activity, memory for personal life experiences (autobiographical memory), and during first-person perspectives and storytelling.[31] Moreover, the DMN is also active during certain "rudimentary" cognitive processes, including perception, action, and emotion.[32] The pattern of this activity has led to hypotheses about the role of the DMN in the integration and binding of experiences to produce consciousness.[33] Importantly, just like other networked neural activity, activity in this network should not be understood as all or nothing; some tasks (i.e., thinking about familiar others) activate one portion of the network, whereas other tasks (i.e., thinking about oneself) activate the network differently.[34] However, across studies that examine these differential patterns of activation, research generally converges on the conclusion that the regions labeled as the DMN are active when individuals engage in self-referential mental activities.

One important aspect of the DMN is that the increased activation in the DMN during internally directed self-reflections *decreases* when cognitive activity is oriented externally.[35] This is one of the distinguishing features of the DMN compared to other resting-state networks, the latter of which do not anticorrelate with externally oriented attentional networks.[36] For example, Fox and colleagues present data showing that when individuals engage in an attention-demanding task (i.e., actively listening or studying a visual array), the neural activation in the cortical areas associated with hearing and vision increases relative to baseline (which would be expected). This activation is *negatively* correlated, or anticorrelated, with activity in the DMN. As individuals dedicate more attention to the *external* world, increasing activity in those brain networks, activity in the DMN, responsible for monitoring the *internal* world, decreases.[37]

Research has demonstrated that the DMN undergoes development. The DMN of children is underdeveloped/differently connected compared to the healthy human adult DMN.[38] On its own, this finding should not be surprising considering general principles of brain growth, maturation, and experience-dependent plasticity.[39] Underlying brain development coincides with children's psychological development—for example, in their increasing capacity for self-recognition, narrative, first-person perspective memory, and theory of mind.[40] Brains, cognitive capacities, and behavior are deeply intertwined.[41] Given that the healthy functioning of the DMN includes a strong anticorrelation with external attention networks, research has increasingly started exploring the relationship between brain development, behavior, and attentional difficulties across development. For example, the disrupted distinction between the DMN and external attention networks associated with media multitasking may explain concerns about attention switching and emotion regulation among children and adolescents with problematic internet use.[42]

In typically developing adult humans, this inverse on/off relationship between DMN activation (internal attention, attention of self) and the activation of other, externally oriented attentional networks has been explored in research on the regulation of self. Consider, for example, the neural mechanisms undergirding media multitasking. When individuals' attention is persistently and pervasively orientated outward, such as in the replacement of internally reflective moments (e.g., the boredom of waiting in a line) with the scroll through social media while simultaneously listening to a podcast and checking for email or text notifications, the neural networks responsible for monitoring "out there" are strengthened. The net implication is a weakening, through disuse, of the intrinsic system that undergirds the capacity to filter out future external distractions.[43] Although the brain comes prepared with specific genetically scripted ways of developing, its great power is the capacity to be shaped according to its environmental input. Just as exercise strengthens the muscles that are worked according to how they are

worked, a brain develops and strengthens networks according to their use.[44]

Given the research highlighting the consistent role of the DMN in self-processing, a reasonable question to follow concerns the extent to which disruptions to the DMN lead to significant disruptions to selves, such as in the case of excessive media multitasking or problematic internet use. Although the DMN and external task attention networks are anticorrelated in a healthy brain, research indicates a number of disorders marked by disturbances to the typical anticorrelations between the DMN and external attention networks or within the internal connectivity of the DMN. For example, disturbances in DMN connectivity have been implicated in autism spectrum disorder, major depressive disorder, and post-traumatic stress disorder.[45] Disturbances can also include hyperactivation of the DMN, which disturbs *when* this network activates, as is the case in bipolar disorder and psychosis.[46] These disturbances involve atypical patterns of activation, such as found among individuals with major depressive disorder. Specifically, those with major depressive disorder had patterns of increased and decreased activation within the DMN that were inverted compared to those without major depression.[47] This pattern of hyper/diminished activation points to the relationship between depression and increased self-focus and internally directed rumination.[48] Just as it is likely too simplistic to say that a "self is DMN," it is likely too simplistic to attribute disorders of self to disorders of the DMN. Yet, as researchers have pointed out, activity in the DMN is a primary contributor to consciousness and self-awareness, making disturbances to the DMN especially meaningful in understanding disorders related to self, even if the DMN cannot fully account for the production of the consciousness that yields self-awareness.[49]

On the other side of disorder, there is evidence that treatments for a variety of psychological problems have increased or decreased effectiveness as a function of individual DMN connectivity. For example, individuals with schizophrenia with lower levels of pretreatment DMN connectivity experience a diminished response to antipsychotic medications, thus experiencing the disorder more severely.[50] Likewise, recent review evidence suggests that the effectiveness of mindfulness interventions in alleviating psychological distress may be related to the extent of changes in DMN connectivity. Specifically, mindfulness interventions may engage the DMN in self-regulation around the direction of attention, especially away from the maladaptive, internal rumination associated with psychological problems such as anxiety and depression.[51]

This research converges on the conclusion that activity in the DMN is central to a coherent and healthy sense of self; disruptions in this network correspond with associated disruptions to selves. The next question concerns the extent to which the self is synonymous with the DMN. In the following section, I review one theory that begins to address this question.

The Baseline Self

Although the data presented in this body of research are compelling, the nature of their interpretation is relatively controversial, such that even papers arguing for a particular understanding for the DMN often start with a disclaimer that there is currently no scientific consensus about the DMN generally, nor whether it should be understood as a marker of a specialized system for self specifically.[52] This lack of scientific consensus has, in many ways, spurred additional theory and interpretations to guide research in the hopes of developing understanding and consensus. One of these theories concerning the DMN is offered by Georg Northoff, in which he argues for the foundational nature of self-as-object in brain processing. Self-as-object is in contrast to self-as-subject, which is a subjective, first person, conscious experience of "I." In his "basis model of self," Northoff suggests that rather than the self as a higher-order, emergent cognitive structure, self-as-object may be fundamental to all cognitive processes. Self-related processing, which is understood as nonpsychological, implicit neural activity for self-as-object, is differentiated from self-referential activity, which is driven by content and representation of self at a psychological level (i.e., self-as-subject, who I perceive myself to be). Northoff argues that self-related processing prioritizes self in neural activity such that other cognitive functions should be understood as emerging out of an inherent and baseline self-specificity; that there is not just overlap between the activity in the resting state DMN and self-related processes, but that self-specificity is encoded (contained) in the neural activities of the brain a priori to other, externally activated cognitive functions. In essence, rather than self-related processing emerging

from other cognitive functions (e.g., perception, emotions), Northoff suggests that the data imply an interpretation in the *other* direction. Specifically, he interprets research on the brain's intrinsic activity—activity in the DMN—as a neural encoding of the self that undergirds these other functions.[53] Although Northoff's argument is primarily interested in neural activity (i.e., nonpsychological; not a subjective sense of "who I am" as self), subsequent work from this theoretical vantage suggests that self in this kind of model also has meaning as a *psychological* baseline that corresponds with a first-person, subjective experience that is meaningfully connected to the psychological experience of self (concerning self-related content and self-representations).[54]

Specifically, Scalabrini and colleagues interpret their data by stating that the self is "the default, reference, or psychological baseline for its own spectrum of thought."[55] Sui and Humphreys argued a similar conclusion in suggesting that self-reference activity involving DMN activation is what binds the distributed processing of neural activity together into an experienced, coherent whole. This binding is what provides a unified sense of self, others, world, and action despite the parsed and distributed nature of the brain's neural activity.[56] Sui argues that the significance of the self (and the DMN activation maintaining it) to conscious experience suggests that the self is not an epiphenomenal illusion.[57] Instead, consistent with Northoff's basis model of self, self-related processing may be foundational to all human neural activity, a necessary point of reference or baseline.

Northoff's argument points to an important feature of current scientific understanding related to the DMN. Although there is an impressive and growing list of activities that the DMN coordinates and undergirds, these activities require interpretation within a theoretical framework, making current theory-building a particularly important and dynamic activity. It is at this juncture that it is important to proceed cautiously; rather than accepting a theoretical explanation that may be underdetermined by the data or seizing onto simple but likely incomplete explanations, it is important to remember that data are interpreted.[58] Theoretical disagreements are important as they fuel scientific progress; they can also provide viable opportunities for interdisciplinary contributions.[59] In his paper, Northoff explicitly addresses the need for reconsideration of empirical models built on a set of philosophical assumptions.[60] It is in light of the possibility of fruitful interdisciplinary engagement at the nexus of scientific disagreement that I pursue this discussion.

Taken together, this body of research yields a tentative answer to a question raised above, concerning the potential for a neural baseline: there does appear to be a meaningful neural baseline of intrinsic brain activity, the activity of the DMN.[61] Moreover, though also more controversially, this DMN activity represents a fundamental and coherent neural network underpinning self-related processing and psychological concepts of self. This interpretation, even as it is debated, opens the possibility of asking the question concerning what such a neural network implies about human persons. I address two aspects of this question below: the first, examining how to think about scientific data and interpretation about selves; and the second, examining how research on the DMN may contribute to models of human telos.

Interdisciplinary Possibilities around Selves

In light of the previous discussion, my goal in what follows is not to offer definitive assessments of "self" based on the dynamic and varied theoretical interpretations of the default mode network (DMN). Instead, my goal is to engage this science as a Christian, asking whether and how theological commitments may influence an interpretation of the research on the DMN (see Selves and Scientific Interpretation below), and whether or how this research might inform ongoing Christian practice and formation (see Selves and Telos below). I aim to resist the allure of a simple "DMN is self" interpretation, which is a simplification of theories such as Northoff's *basis model of self* to the point of distortion. Instead, I hope that emerging data around the DMN may open possibilities for reflection and interdisciplinary dialogue. I am *not* arguing that selves *are* DMNs, an important assertion, as this claim would call into question the personhood of those with diminished DMNs (e.g., children, dementia patients) while implying that animals with DMN-like structures may be persons.[62] For scientific and for theological reasons, I do not think it is defensible to claim that a self/person is defined by and reducible to the DMN. Rather, I am suggesting that research aimed at understanding and interpreting the data concerning the DMN may benefit from

philosophical and theological perspectives and, vice versa, may glean insights relevant to robust theological, philosophical, and historical debates about selves from the nascent and vibrant discussions about how to understand the DMN. Caveats notwithstanding, in what follows I suggest that research on the DMN has the potential to enliven interdisciplinary insight for the interpretation of DMN-related data and theory development and invite dialogue around what selves are *for*.

Selves and Scientific Interpretation

A primary controversy around the DMN concerns the appropriate interpretation for what function it serves and whether that function should be understood as a baseline for and central ingredient of a self. This controversy is directly related to the equally difficult question of the origin and nature of self-awareness and consciousness. Given this controversy, the emerging theory to interpret and explain DMN data may be especially well poised to benefit from non-empirical contributions. This includes thinking through how various philosophical commitments about the nature of self may yield different interpretations of the same data. Different data-consistent interpretations are possible because interpretation, explanation, and theory building involve assumptions that are not inherent in the data themselves.

Thus, a philosophical commitment that the self is epiphenomenal or that the self is meaningful will produce different inclinations for the interpretation of the DMN's function. Given the current debate, it is scientifically defensible to argue for self as more than an illusion, bearing in mind that this is an interpretation of data rather than self-evident in the data. It is important, however, that philosophical commitments and scientific progress be in dialogue. Commitments may change as data overwhelmingly point to specific conclusions in the same way that philosophical commitments can push science to ask different questions yielding new insights.[63] A clear recognition of the place of these kinds of philosophical commitments is important because, although science is without an explicit metaphysical framework, it is often wielded such as to assume metaphysical naturalism. This assumption prioritizes the findings of science as sufficient to explain (and explain away) the whole of human experience (including the perception of self).[64]

Earlier, I argued that a reduction of self to DMN was insufficient based on scientific *and* theological commitments. These commitments complicate an alluring but oversimplified story of self as DMN in a way that requires better theory development. For example, an investigation beyond what is possible in this review suggests that the self may be both fundamental (in the sense of DMN) *and* a higher-order, emergent property.[65] This entails two implications. One implication is that a simple "self-as-DMN" explanation of persons is insufficient. This is not, perhaps, surprising, given that some tasks, such as self-recognition or esteem-related thought, are not contained within DMN activity but are still related to self.[66] Rather than reducing the self to a single brain network, there should be sufficient caution to maintain an appropriate balance of skepticism alongside the possibilities offered in the theory and interpretation of the function of the DMN. Though the data clearly inform the articulated perspectives, it is possible that this disagreement is less about these data and more about the (implicit) philosophical assumptions undergirding their interpretation.

A second implication of these competing models, then, is that even within the brain there are different levels at which the self can be reduced to: the default baseline and an emergent, higher-order construct. Together, this research suggests that both levels of understanding may be correct. The self is, in some sense, reducible to the most fundamental circuit of the brain and it is, at the same time, more than this reduction as an integrative output of the brain. This should not be surprising, given that the brain is a complex system in which multiple interacting and competing systems produce and are shaped by cognition and behavior.[67] At minimum, the self, when examined with the language of neuroscience, requires the kind of robust analysis that includes fundamental and emergent aspects. If these levels of explanation are required *within* the brain, why would they not be required in thinking about the self *beyond* the brain? The multiple layers by which the self can be understood may echo the Hebrew understanding of self as *nephesh*. Even though English translations use words like "soul" and "spirit" (connotating something separate from body), there is a consensus among biblical scholars that these terms refer to the wholeness of a human person.[68] Perhaps a view of self as both fundamental and as an emergent whole might provide a new language for theological

arguments around mind/soul/bodies. The multiple layers of self from a neuroscientific perspective may enliven equivalent analyses in theological thought about selves.

Selves and Telos

A second interdisciplinary opportunity emerging from DMN research is related to thinking about what selves are *for:* the purpose, direction, and telos of selves. In a theological view of developmental psychology, Balswick, King, and Reimer introduce the concept of the *developmental dilemma*.[69] The dilemma is that developmental psychology, though intended to describe, explain, and optimize human behavior, is unable to provide a robust and compelling vision for telos. Data (though not scientists) are agnostic on the issue of whether one set of life outcomes is optimal relative to another set of outcomes. For example, although data can (and does) reveal that spending money for the benefit of others increases happiness relative to spending money on oneself, data cannot defend the assertion that this increase in happiness is something to be desired.[70] Although researchers may point to the associations between happiness and other outcomes such as longevity or relationship quality, this simply moves the target as these other outcomes cannot be defended as good or bad by the data alone. In this sense, data require a framework that is robust *beyond* empirical observations in order to contextualize the meaningfulness of the data. It is in this vein that I believe research on the DMN can produce an enriching dialogue with Christian theology and tradition, both of which can provide a context beyond the empirical observations within which one can ask how an understanding of healthy DMN development may adjudicate between competing interpretations of and visions for Christian practice.

An examination of when and how the DMN functions properly, can yield insight into the purpose of self, insight that may produce meaning within a Christian framework. Consider the analogy of a tool. Although a tool has a purpose, it may be used outside of its intended design. However, consistent misuse against its intended purpose may cause significant and long-term damage to the tool. By examining the pattern of damage to the tool, it is possible to better understand what the tool is *not* for, leaving fewer options available for considering its intended telos. It is this kind of understanding that patterns of DMN activity and disruption might provide—an understanding that has implications for personal and corporate Christian practice. Although brain networks may initially have primary functions, they are constantly co-opted to serve additional purposes.[71] When such a co-opting yields significant damage or distress—for example, to self in the case of the disorders described above—this suggests that the network is no longer operating within its normal, intended function. The implication is that the current function is beyond the sustainable scope of the network's purpose.

The DMN is a neural network active during internal, reflective, and nondirected thought linked to selves. In a healthy brain, its activity *necessarily precludes* the kind of externally directed attention that is required to think about others. That is, the DMN works antagonistically with externally oriented attention networks; activating the DMN attenuates activity in outward focused attention networks and vice versa. Mary Helen Immordino-Yang and colleagues reviewed evidence for the importance of this kind of internal reflective activity supported by the DMN for healthy socioemotional development. They concluded that individuals with stronger within-DMN coordination and with more differentiated "on/off" switches (i.e., stronger anticorrelation) between DMN activity and externally oriented attention network activity score higher on a number of measures of cognitive and social abilities compared to those with less coordinated and less differentiated networks. Thus, they promote educational activities that engage *constructive internal reflection,* as means to develop stronger intranetwork coordination and internetwork decoupling.[72] The suggestion that internal reflective behaviors can change brain connectivity is supported by research demonstrating how mindfulness interventions change the functional connectivity of the DMN. More generally, this suggestion is consistent with principles of brain plasticity, that changes in behavior can shape (and reshape) patterns of neural activity and networking.[73]

Broadly, recommendations for healthy DMN development are similar to general recommendations for health, including consistently getting enough sleep, exercise, and eating a healthy diet.[74] More specifically, however, the scope of activities supported by the DMN suggests at least three particular relational and behavioral patterns that reinforce healthy functioning of the DMN: (1) cultivating interpersonal relationships that develop empathy and emotional

intelligence; (2) practicing contemplation and reflection; and (3) the regular exercise of self-regulation, especially as related to media multitasking and the impulse to fill moments of bored mind-wandering with entertainment and externally oriented engagement.[75] Given the relationship between behavior and brain development, the development of healthy DMNs requires behaving and interacting in a way that supports the neural developments of these capacities in the first place.

These three suggestions to engage in healthy interpersonal relationships, quiet contemplation, and measured self-regulation reflect values embedded within Christian communities. Todd and Liz Hall, for example, provide an exceptional review of the role and importance of the local church as more than a building to be visited, but an interpersonal means for formation. Formation involves transformation of self and behavior that can be understood as reflective of changes in brain connectivity and processing. The first interpersonal relationship between parent and child has particular importance in shaping future relationships via neural and psychological mechanisms.[76] Specific to DMN development, consider the recent research indicating that the strength of parental religious belief influenced the connectivity of their adolescent children's DMN; one possible interpretation is that the nature of parents' religious beliefs influenced how adolescents viewed themselves as reflected in stronger activation within particular locations of the DMN.[77] Moreover, interpersonal relationships within the church can be a critical source of healing and transformation. Consider research demonstrating the importance of church ministry for children's ability to cultivate loving, supportive relationships, and the role of these ministries in promoting healing among children who have experienced trauma.[78] Importantly, one of the best predictors of church communities that support children's relational development and resilience in the face of trauma is the children's ministry's use of contemplative-reflective practices, practices which are likely to engage the DMN given the similarity to mindfulness practices known to engage the DMN.[79]

Regarding quiet contemplation, there is considerable overlap between constructs such as mindfulness and constructive internal reflection (both of which support healthy DMN activation), on the one hand, and Christian spiritual disciplines, on the other. Voices such as Richard Foster and Dallas Willard point to the importance of spiritual disciplines such as solitude, meditation, simplicity, and service in Christian formation, disciplines that date back to the early church.[80] More recently, Christian psychologists have worked to reclaim these practices as a theistic and theologically grounded replacement for contemporary mindfulness rooted in Buddhism.[81] It seems that mindfulness or constructive internal reflection is good for individuals' psychological experience and their DMN. More importantly, it also seems that these practices are rooted in the formative experiences well known to the early church, experiences to which individuals such as Willard and Foster call the church to return.

The third and final suggestion to develop a healthy DMN is perhaps the most familiar to Christians, to practice measured self-regulation. In fact, at this point one might think that the goal of these activities is merely to "look inward" more, to exercise self-control, to meditate and ponder Christ. This conclusion, however, is premature. Many cases of disorder linked to disruption in the DMN is connected to *hyper*activation of this network.[82] It seems that healthy brains, with respect to the DMN, have a specific balance in the networks that support inwardly directed attention (attention to self) and outwardly direction attention (attention to others). Mark McMinn, for example, understands virtue as the telos of Christian formation, entailing the proper orientation to and balance of self and other focus in light of God's love.[83] Formation toward Christlikeness involves both solitude *and* service; it involves both inward reflection *and* external attention, each at its proper time. That means self-regulation serves to enable the development of "proper time" capacity. This capacity entails reflection, meditation, and the internal disciplines of preparing and prompting individuals for external attention and service, which then call individuals to return to reflection and meditation. This cycle is contrary to the multitask mentality of modern culture where individuals neither attend internally nor externally with intention and control: this is a behavioral practice with neurological and psychological ramifications.[84] Just as a tool might break if used incorrectly, when human behavior is inconsistent with intended purpose—by either looking too much inward or being too distracted by the outward—there are measurable changes in brain and behavior, changes associated with dysfunction.

Conclusion

In this article, I presented neuroscience theory that suggests selves may be fundamental to the brain in the default mode network (DMN). In this interpretation, selves also serve as a psychological baseline by which we make sense of and engage everything else. Importantly, when the DMN is active (e.g., during quiet self-reflection), brain systems engaging the external world are not; when attention is directed externally (e.g., in talking with others), activity in the DMN is diminished. This pattern of activity is the marker of a healthy brain and a robust self, including the more emergent, higher-order functions of self.

This line of research seems well positioned to contribute to and benefit from the interdisciplinary dialogue in theological anthropology in at least two ways. First, this body of research provides an opportunity to explicitly work through how philosophical commitments influence the interpretation of data. This exercise is good for science, but it can also positively influence the more general science-religion dialogue by identifying the range of possible beliefs within the scope of orthodox Christianity. This kind of "Christian identity expansion" is an important feature of bridging the perceived gaps between science and Christianity.[85] One of the possibilities of this exercise is the conclusion that, neurologically, the self may be a meaningful construct. Although brains are best understood as competing and distributed networks of activity, the self may undergird all this activation in a significant and fundamental manner. The current scientific debates around this theoretical interpretation can benefit from philosophical assessment and also contribute new framework and language within the scope of theological anthropology.

Second, the necessary toggle between contemplative, internal reflection and externally oriented attention/goal-directed tasks offers a significant point of engagement for Christian practice which, as Smith indicates, is grounded in one's theological anthropology.[86] Neuroscience, devoid of an explicit metaphysical narrative structure, cannot make claims about telos; yet drawing from these data about the proper functionality of these internal and external systems may prove useful within a Christian theological framework. Because our understanding of what *kind* of beings we are determines purpose—how we approach discipleship, formation, and goals related to meaningful living—theological considerations of how the DMN works and when it does not may contribute to clarity on a Christian's telos, pastoral decisions around ministry practice, and personal practices for Christian disciplines, among others. Although a lofty goal, it is my hope that such an understanding may highlight the deep need to reinvigorate old Christian practices in worship and contemplation, even amidst the flashy chaos of modern culture. ☼

Notes

[1]Marc Cortez, *Theological Anthropology: A Guide for the Perplexed* (London, UK: T&T Clark, 2010).

[2]Erin I. Smith, "A Tale of Two Perspectives: How Psychology and Neuroscience Contribute to Understanding Personhood," *Scientia et Fides* 9, no. 2 (2021): article 2, https://doi.org/10.12775/SetF.2021.017.

[3]Georg Northoff, "Is the Self a Higher-Order or Fundamental Function of the Brain? The 'Basis Model of Self-Specificity' and Its Encoding by the Brain's Spontaneous Activity," *Cognitive Neuroscience* 7 (2016): 203–22, https://doi.org/10.1080/17588928.2015.1111868.

[4]James K. A. Smith, *You Are What You Love: The Spiritual Power of Habit* (Grand Rapids, MI: Brazos Press, 2016), 2. See also James K. A. Smith, *Desiring the Kingdom: Worship, Worldview, and Cultural Formation* (Grand Rapids, MI: Baker Academic, 2009) for a more technical treatment of the subject.

[5]Cortez, *Theological Anthropology*, 6.

[6]Erin Smith, "A Tale of Two Perspectives."

[7]Northoff, "Basis Model of Self-Specificity."

[8]John T. Cacioppo, Gary G. Berntson, and Howard C. Nusbaum, "Neuroimaging as a New Tool in the Toolbox of Psychological Science," *Current Directions in Psychological Science* 17, no. 2 (2008): 62–67, https://doi.org/10.1111/j.1467-8721.2008.00550.x.

[9]Uri Hasson and Christopher J. Honey, "Future Trends in Neuroimaging: Neural Processes as Expressed within Real-Life Contexts," *NeuroImage* 62, no. 2 (2012): 1272–78, https://doi.org/10.1016/j.neuroimage.2012.02.004.

[10]Philipp Mergenthaler et al., "Sugar for the Brain: The Role of Glucose in Physiological and Pathological Brain Function," *Trends in Neurosciences* 36, no. 10 (2013): 587–97, https://doi.org/10.1016/j.tins.2013.07.001; and Marcus E. Raichle et al., "A Default Mode of Brain Function," *Proceedings of the National Academy of Sciences of the United States of America* 98, no. 2 (2001): 676–82, https://doi.org/10.1073/pnas.98.2.676.

[11]Hasson and Honey, "Future Trends"; Zilu Ma and Nanyin Zheng, "Brain-Wide Connectivity Architecture: Developmental Aspects," in *Factors Affecting Neurodevelopment: Genetics, Neurology, Behavior, and Diet,* ed. Colin R. Martin, Victor R. Preedy, and Rajkumar Rajendram (London, UK: Elsevier, 2021), 247–57, https://doi.org/10.1016/B978-0-12-817986-4.00022-5.

[12]Consider the adjective employed by Northoff, "Basis Model of Self-Specificity," 208, in describing the BOLD signal: *sluggish.*

[13]Ed Bullmore and Olaf Sporns, "Complex Brain Networks: Graph Theoretical Analysis of Structural and Functional Systems," *Nature Reviews Neuroscience* 10, no. 3 (2009): 186–98, https://doi.org/10.1038/nrn2575; and Hasson and Honey, "Future Trends."

[14]Erin Smith, "A Tale of Two Perspectives."

[15]Helder F. Araujo et al., "Neural Correlates of Different Self Domains," *Brain and Behavior* 5, no. 12 (2015): 1–15, https://doi.org/10.1002/brb3.409.

[16]See, for example, the long lists of brain regions associated with different components of self in Seth J. Gillihan and Martha J. Farah, "Is Self Special? A Critical Review of Evidence from Experimental Psychology and Cognitive Neuroscience," *Psychological Bulletin* 131, no. 1 (2005): 81–83, https://doi.org/10.1037/0033-2909.131.1.76; and Brick Johnstone, Daniel Cohen, and Andrew Dennison, "The Integration of Sensations and Mental Experiences into a Unified Experience: A Neuropsychological Model for the 'Sense of Self,'" *Neuropsychologia* 159 (2021): 3, https://doi.org/10.1016/j.neuropsychologia.2021.107939.

[17]Raichle et al., "A Default Mode of Brain Function."

[18]Two notable contributions within neuroscience to understanding selves include Johnstone et al., "Neuropsychological Model"; and Julius Kuhl, Markus Quirin, and Sander L. Koole, "Being Someone: The Integrated Self as a Neuropsychological System," *Social and Personality Psychology Compass* 9, no. 3 (2015): 115–32, https://doi.org/10.1111/spc3.12162.

[19]Raichle et al., "A Default Mode of Brain Function."

[20]Marcus E. Raichle, "The Brain's Default Mode Network," *Annual Review of Neuroscience,* 38, no. 1 (2015): 433–47, https://doi.org/10.1146/annurev-neuro-071013-014030.

[21]Structural networks are described by Yong He, Zhang J. Chen, and Alan C. Evans, "Small-World Anatomical Networks in the Human Brain Revealed by Cortical Thickness from MRI," *Cerebral Cortex* 17, no. 10 (2007): 2407–19, https://doi.org/10.1093/cercor/bhl149. Functional networks are described by Karola Kaefer et al., "Replay, the Default Mode Network and the Cascaded Memory Systems Model," *Nature Reviews Neuroscience* 23 (2022): 628–40, https://doi.org/10.1038/s41583-022-00620-6; Vinod Menon, "Large-Scale Brain Networks in Cognition: Emerging Principles," in *Analysis and Function of Large-Scale Brain Networks,* ed. Olaf Sporns (Washington, DC: Society for Neuroscience, 2010): 45–53.

[22]Ma and Zheng, in "Brain-Wide Connectivity," discuss developmental neurobiological processes; and behavior is addressed by Fengji Geng, Morgan Botdorf, and Tracy Riggins, "How Behavior Shapes the Brain and the Brain Shapes Behavior: Insights from Memory Development," *Journal of Neuroscience* 41, no. 5 (2021): 981–90, https://doi.org/10.1523/JNEUROSCI.2611-19.2020.

[23]The influence of theoretical and methodological choices can be seen in a number of ways, such as in defining brain modules, Danielle S. Bassett and Michael S. Gazzaniga, "Understanding Complexity in the Human Brain," *Trends in Cognitive Sciences* 15, no. 5 (2011): 200–9, https://doi.org/10.1016/j.tics.2011.03.006; and in defining structures or networks, Bullmore and Sporns, "Complex Brain Networks"; Xuhong Liao, Athanasios V. Vasilakos, and Yong He, "Small-World Human Brain Networks: Perspectives and Challenges," *Neuroscience & Biobehavioral Reviews* 77 (2017): 286–300, https://doi.org/10.1016/j.neubiorev.2017.03.018; and Menon, "Large-Scale Brain Networks."

[24]Bullmore and Sporns, "Complex Brain Networks."

[25]Raichle, "Brain's Default Mode Network" provides an overview of the significance of the discovery of the DMN. Michael D. Greicius et al., "Functional Connectivity in the Resting Brain: A Network Analysis of the Default Mode Hypothesis," *Proceedings of the National Academy of Sciences of the United States of America* 100, no. 1 (2003): 253–58, https://www.jstor.org/stable/3074142, explore the functional connectivity of the DMN. Tan Tao et al., "The Structural Connectivity Pattern of the Default Mode Network and Its Association with Memory and Anxiety," *Frontiers in Neuroanatomy* 9 (2015), https://doi.org/10.3389/fnana.2015.00152, explore structural aspects of the DMN.

[26]Raichle et al., "A Default Mode of Brain Function."

[27]Alexa M. Morcom and Paul C. Fletcher dispute the merits of understanding the DMN as a network, "Does the Brain Have a Baseline? Why We Should Resist a Rest," *NeuroImage* 37, no. 4 (2007): 1073–82, https://doi.org/10.1016/j.neuroimage.2006.08.013. However, it is common to have the DMN listed in discussions that provide an overview of the brain's large-scale networks: e.g., Menon, "Large-Scale Brain Networks."

[28]Kaefer et al., "Replay"; and Lewis Mehl-Madrona and Barbara Mainguy, "Neuroscience and Narrative," *Anthropology of Consciousness* 33, no. 1 (2022): 79–95, https://doi.org/10.1111/anoc.12144.

[29]Northoff, "Basis Model of Self-Specificity"; and Pengmin Qin, Niall W. Duncan, and Georg Northoff, "Why and How Is the Self Related to the Brain Midline Regions?," *Frontiers in Human Neuroscience* 7 (2013): 6–7, article 909, https://doi.org/10.3389/fnhum.2013.00909.

[30]Raichle, "Brain's Default Mode Network."

[31]Activity at rest, Raichle et al., "A Default Mode of Brain Function"; during mind-wandering, Georg Northoff, "How Does the Brain's Spontaneous Activity Generate Our Thoughts? The Spatiotemporal Theory of Task-Unrelated Thought (STTT)" in *The Oxford Handbook of Spontaneous Thought: Mind-Wandering, Creativity, and Dreaming,* ed. Kieran C. R. Fox and Kalina Christoff (New York: Oxford University Press, 2018), 55–70, https://doi.org/10.1093/oxfordhb/9780190464745.013.9; during self-referential mental activity, Christopher G. Davey, Jesus Pujol, and Ben J. Harrison, "Mapping the Self in the Brain's Default Mode Network," *NeuroImage* 132 (2016): 390–97, https://doi.org/10.1016/j.neuroimage.2016.02.022; Georg Northoff et al., "Self-Referential Processing in Our Brain: A Meta-Analysis of Imaging Studies on the Self," *NeuroImage* 31, no. 1 (2006): 440–57, https://doi.org/10.1016/j.neuroimage.2005.12.002; Pengmin Qin and Georg Northoff, "How Is Our Self Related to Midline Regions and the Default-Mode Network?," *NeuroImage* 57, no. 3 (2011): 1221–33, https://doi.org/10.1016/j.neuroimage.2011.05.028; during memory for personal life experiences, Kaefer et al., "Replay"; and during first-person perspectives and storytelling, Andrew A. Fingelkurts and Alexander A. Fingelkurts, "Persistent Operational Synchrony within Brain Default-Mode Network and Self-Processing Operations in Healthy Subjects," *Brain and Cognition* 75, no. 2 (2011): 79–90, https://doi.org/10.1016/j.bandc.2010.11.015; and Mehl-Madrona and Mainguy, "Neuroscience and Narrative."

[32]Northoff, "Basis Model of Self-Specificity"; and Jie Sui and Glyn W. Humphreys, "The Integrative Self: How Self-Reference Integrates Perception and Memory," *Trends in*

Cognitive Sciences 19, no. 12 (2015): 719–28, https://doi.org/10.1016/j.tics.2015.08.015.

[33]Mehl-Madrona and Mainguy, "Neuroscience and Narrative"; Jie Sui, "Self-Reference Acts as a Golden Thread in Binding," *Trends in Cognitive Sciences* 20, no. 7 (2016): 482–83, https://doi.org/10.1016/j.tics.2016.04.005; Edward Vessel, G. Gabrielle Starr, and Nava Rubin, "The Brain on Art: Intense Aesthetic Experience Activates the Default Mode Network," *Frontiers in Human Neuroscience* 6 (2012): article 66, https://doi.org/10.3389/fnhum.2012.00066; Jun Zhang et al., "Abnormal Default Mode Network Could be a Potential Prognostic Marker in Patients with Disorders of Consciousness," *Clinical Neurology and Neurosurgery* 218 (2022): 107294, https://doi.org/10.1016/j.clineuro.2022.107294.

[34]Araujo et al., "Neural Correlates"; Qin and Northoff, "Is Our Self Related to Midline Regions?"

[35]Michael D. Fox et al., "The Human Brain Is Intrinsically Organized into Dynamic, Anticorrelated Functional Networks," *Proceedings of the National Academy of Sciences of the United States of America* 102, no. 27 (2005): 9673–78, https://doi.org/10.1073/pnas.0504136102; and Raichle, "Brain's Default Mode Network."

[36]Kaefer et al., "Replay."

[37]Fox et al., "Human Brain."

[38]J. Cui et al., "Microstructure of the Default Mode Network in Preterm Infants," *American Journal of Neuroradiology* 38, no. 2 (2017): 343–48, http://dx.doi.org/10.3174/ajnr.A4997; and Kaustubh Supekar et al., "Development of Functional and Structural Connectivity within the Default Mode Network in Young Children," *NeuroImage* 52, no. 1 (2010): 290–301, https://doi.org/10.1016/j.neuroimage.2010.04.009.

[39]Uma R. Karmarkar and Yang Dan, "Experience-Dependent Plasticity in Adult Visual Cortex," *Neuron* 52, no. 4 (2006): 577–85, https://doi.org/10.1016/j.neuron.2006.11.001; and Patrice Voss et al., "Dynamic Brains and the Changing Rules of Neuroplasticity: Implications for Learning and Recovery," *Frontiers in Psychology* 8 (2017): 1657, https://doi.org/10.3389/fpsyg.2017.01657.

[40]Concerning self-recognition: Kristin Hansen Lagattuta and Ross A. Thompson, "The Development of Self-Conscious Emotions: Cognitive Processes and Social Influences," in *The Self-Conscious Emotions: Theory and Research,* ed. Jessica L. Tracy, Richard W. Robins, and June Price Tangney (New York: The Guilford Press, 2007), 91–113; and Michael Lewis and Jeanne Brooks-Gunn, "Chapter 8: The Development of Self Recognition," in *Social Cognition and the Acquisition of Self* (New York: Plenum Press, 1979): 198–221. Concerning narrative and first-person perspective memory: Patricia J. Bauer, Marina Larkina, and Joanne Deocampo, "Chapter 6: Early Memory Development," in *The Wiley-Blackwell Handbook of Childhood Cognitive Development,* second edition, ed. Usha Goswami (West Sussex, UK: Wiley-Blackwell, 2011), 153–79; and Geng et al., "Behavior Shapes the Brain." Concerning theory of mind: Rogier Mars et al., "On the Relationship between the 'Default Mode Network' and the 'Social Brain,'" *Frontiers in Human Neuroscience* 6 (2012): 189, https://doi.org/10.3389/fnhum.2012.00189; and Henry M. Wellman, David Cross, and Julanne Watson, "Meta-Analysis of Theory-of-Mind Development: The Truth about False Belief, *Child Development* 72, no. 3 (2001): 655–84, http://www.jstor.org/stable/1132444.

[41]John W. Krakauer et al., "Neuroscience Needs Behavior: Correcting a Reductionist Bias," *Neuron* 93, no. 3 (2017): 480–90, https://doi.org/10.1016/j.neuron.2016.12.041; and Voss et al., "Dynamic Brains."

[42]William M. Kelley, Dylan D. Wagner, and Todd F. Heatherton, "In Search of a Human Self-Regulation System," *Annual Review of Neuroscience* 38, no. 1 (2015): 389–411, https://doi.org/10.1146/annurev-neuro-071013-014243; and Kristiana Siste et al., "Altered Resting-State Network in Adolescents with Problematic Internet Use," *Journal of Clinical Medicine* 11, no. 19 (2022): 5838, https://doi.org/10.3390/jcm11195838.

[43]Kelley et al., "Self-Regulation System."

[44]Voss et al., "Dynamic Brains."

[45]Weijie Bao et al., "Alterations in Large-Scale Functional Networks in Adult Posttraumatic Stress Disorder: A Systematic Review and Meta-Analysis of Resting-State Functional Connectivity Studies," *Neuroscience and Biobehavioral Reviews* 131 (2021): 1027–36, https://doi.org/10.1016/j.neubiorev.2021.10.017; Jianxiu Li et al., "Abnormal Core Functional Connectivity on the Pathology of MDD and Antidepressant Treatment: A Systematic Review," *Journal of Affective Disorders* 296 (2022): 622–34, https://doi.org/10.1016/j.jad.2021.09.074; and Aarthi Padmanabhan et al., "The Default Mode Network in Autism," *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging* 2, no. 6 (2017): 476–86, https://doi.org/10.1016/j.bpsc.2017.04.004.

[46]Randy L. Buckner, "The Brain's Default Network: Origins and Implications for the Study of Psychosis," *Dialogues in Clinical Neuroscience* 15, no. 3 (2013): 351–58, https://doi.org/10.31887/DCNS.2013.15.3/rbuckner; and Tina Chou et al., "Restoration of Default Mode Network and Task Positive Network Anti-Correlation Associated with Mindfulness-Based Cognitive Therapy for Bipolar Disorder," *Psychiatry Research: Neuroimaging* 319 (2022): 111419, https://doi.org/10.1016/j.pscychresns.2021.111419.

[47]Georg Northoff and E. Sibille, "Why are Cortical GABA Neurons Relevant to Internal Focus in Depression? A Cross-Level Model Linking Cellular, Biochemical, and Neural Network Findings," *Molecular Psychiatry* 19 (2014): 966–77, https://doi.org/10.1038/mp.2014.68.

[48]Northoff, "Basis Model of Self-Specificity."

[49]Jian Li et al., "Mapping the Subcortical Connectivity of the Human Default Mode Network," *NeuroImage* 245 (2021): 118758, https://doi.org/10.1016/j.neuroimage.2021.118758.

[50]Urvakhsh Meherwan Mehta et al., "Resting-State Functional Connectivity Predictors of Treatment Response in Schizophrenia—A Systematic Review and Meta-Analysis," *Schizophrenia Research* 237 (2021): 153–65, https://doi.org/10.1016/j.schres.2021.09.004.

[51]Michelle Melis et al., "The Impact of Mindfulness-Based Interventions on Brain Functional Connectivity: A Systematic Review," *Mindfulness* 13, no. 8 (2022): 1857–75; and Hadley Rahrig et al., "Meta-Analytic Evidence That Mindfulness Training Alters Resting State Default Mode Network Connectivity," *Scientific Reports* 12 (2022): 12260, https://doi.org/10.1038/s41598-022-15195-6.

[52]Gillihan and Farah, for example, in "Is Self Special?," argue that there is not sufficient evidence that a self-system is *special*, something that is anatomically distinct, processed differently than other kinds of systems, independent of other systems, and specific to humans. Moran, Kelley, and Heatherton likewise argue that the

self-system should be understood as any other cognitive system, just more powerful in directing activities, in Joseph Moran, William Kelley, and Todd Heatherton, "What Can the Organization of the Brain's Default Mode Network Tell Us about Self-Knowledge?," *Frontiers in Human Neuroscience* 7 (2013): 391, https://doi.org/10.3389/fnhum.2013.00391. Northoff, on the other hand, in "Basis Model of Self-Specificity," presents evidence that self-related processing is the foundation of other cognitive processes and is contained within the intrinsic activity of the brain. Scalabrini et al. have found a psychological correspondence for this containment regarding self, in Andrea Scalabrini et al., "The Self and Its Internal Thought: In Search for a Psychological Baseline," *Consciousness and Cognition* 97 (2022): 103244, https://doi.org/10.1016/j.concog.2021.103244. Kaefer, in "Replay," provides an example of the utility of investigating the networked activity of the DMN in understanding broader cognitive processes, such as memory, even while the specific function and interpretation of the DMN is debated.

[53]Northoff, "Basis Model of Self-Specificity."

[54]Scalabrini, "Psychological Baseline."

[55]Ibid., 2.

[56]Sui and Humphreys, "Integrative Self."

[57]Sui, "Self-Reference."

[58]This warning is fueled, in part, by a retrospective reflection on the scientific and public craze around mirror neurons which were used to try to explain nearly everything having to do with social cognition in the 2000s. Many of these claims were overstated and oversimplified. Cecilia Heyes, "Mesmerising Mirror Neurons," *NeuroImage* 51, no. 2 (2010): 789–91, https://doi.org/10.1016/j.neuroimage.2010.02.034; and Cecilia Heyes and Caroline Catmur, "What Happened to Mirror Neurons?," *Perspectives on Psychological Science* 17, no. 1 (2022): 153–68, https://doi.org/10.1177/1745691621990638.

[59]For an example of disagreements promoting understanding in specific scientific contexts, see Daniel Kahneman and Gary Klein, "Conditions for Intuitive Expertise: A Failure to Disagree," *American Psychologist* 64, no. 6 (2009): 515–26, https://doi.org/10.1037/a0016755. For an analysis of the nature of disagreement in science, see Wout S. Lamers et al., "Meta-Research: Investigating Disagreement in the Scientific Literature," *eLife* 10 (2021): e72737, https://doi.org/10.7554/eLife.72737. See Erin Smith, "A Tale of Two Perspectives," for suggestions for interdisciplinary contributions.

[60]Northoff, "Basis Model of Self-Specificity."

[61]However, as mentioned previously, there is a seemingly minority interpretation that intrinsic activity should not be understood as a functional network: see Morcom and Fletcher, "Resist a Rest." More recently, evidence has also suggested that the DMN may be better understood as multiple, interconnected networks rather than as a single network: see Randy L. Buckner and Lauren M. DiNicola, "The Brain's Default Network: Updated Anatomy, Physiology, and Evolving Insights," *Nature Reviews Neuroscience* 20, no. 10 (2019): 593–608, https://doi.org/10.1038/s41583-019-0212-7.

[62]For the development of DMN in pre-term infants and children, see Damien A. Fair et al., "The Maturing Architecture of the Brain's Default Network," *Proceedings of the National Academy of Sciences of the United States of America* 105, no. 10 (2008): 4028–32, https://doi.org/10.1073/pnas.0800376105; Huiqing Hu, Rhodri Cusack, and Lorina Naci, "Typical and Disrupted Brain Circuitry for Conscious Awareness in Full-Term and Preterm Infants," *Brain Communications* 4, no. 2 (2022): fcac071, https://doi.org/10.1093/braincomms/fcac071; and Supekar et al., "Development." For DMN changes in Alzheimer's patients, see Anne Hafkemeijer, Jeroen van der Grond, and Serge A. R. B. Rombouts, "Imaging the Default Mode Network in Aging and Dementia," *Biochimica et Biophysica Acta (BBA) – Molecular Basis of Disease* 1822, no. 3 (2012): 431–41, https://doi.org/10.1016/j.bbadis.2011.07.008. For a discussion of differences in human and primate DMNs, see Clément M. Garin et al., "An Evolutionary Gap in Primate Default Mode Network Organization," *Cell Reports* 39, no. 2 (2022): 110669, https://doi.org/10.1016/j.celrep.2022.110669. For a discussion on rat DMNs, see Hanbing Lu et al., "Rat Brains Also Have a Default Mode Network," *Proceedings of the National Academy of Sciences of the United States of America* 109, no. 10 (2012): 3979, https://doi.org/10.1073/pnas.1200506109. For a general discussion of the DMN that briefly addresses many of these individual items, see Ma and Zheng, "Brain-Wide Connectivity."

[63]See, for example, the description of the role of philosophy vis-à-vis science in Alex Rosenberg, *Philosophy of Science: A Contemporary Introduction,* third edition (New York: Routledge, 2012), 1–18.

[64]Erin Smith, "A Tale of Two Perspectives."

[65]Kuhl et al., "Being Someone."

[66]Moran et al., "Self-Knowledge."

[67]Bullmore and Sporns, "Complex Brain Networks"; Geng et al., "Behavior Shapes the Brain"; and Voss et al., "Dynamic Brains."

[68]Cortez, *Theological Anthropology*, 70. This consensus does not imply that there is agreement about the particularities of the composition of these wholes: most scholars agree that scripture authors were interested in the whole of an embodied person, not just specific components housed within a person.

[69]Jack O. Balswick, Pamela Ebstyne King, and Kevin S. Reimer, *The Reciprocating Self: Human Development in Theological Perspective,* second edition (Downers Grove, IL: IVP Academic, 2016), 19–27.

[70]Elizabeth W. Dunn, Lara B. Aknin, and Michael I. Norton, "Spending Money on Others Promotes Happiness," *Science* 319, no. 5870 (2008): 1687–88, https://www.science.org/doi/10.1126/science.1150952.

[71]Michael L. Anderson, "Neural Reuse: A Fundamental Organizational Principle of the Brain," *Behavioral and Brain Sciences* 33, no. 4 (2010): 245–66, https://doi.org/10.1017/S0140525X10000853.

[72]Mary Helen Immordino-Yang, Joanna A. Christodoulou, and Vanessa Singh, "Rest Is Not Idleness: Implications of the Brain's Default Mode for Human Development and Education," *Perspectives on Psychological Science* 7, no. 4 (2012): 352–64, https://doi.org/10.1177/1745691612447308.

[73]Melis et al., "Mindfulness-Based Interventions"; Rahrig et al., "Meta-Analytic Evidence"; and Voss et al., "Dynamic Brains."

[74]Jessica R. Lunsford-Avery et al., "Sleep/Wake Regularity Associated with Default Mode Network Structure among Healthy Adolescents and Young Adults," *Scientific Reports* 10, no. 1 (2020): 509, https://doi.org/10.1038/s41598-019-57024-3 ; Mo-Yi Li et al., "The Effects of Aerobic Exercise on the Structure and Function of DMN-Related Brain Regions: A Systematic Review," *The International Journal*

of Neuroscience 127, no. 7 (2017): 634–49, https://doi.org/10.1080/00207454.2016.1212855; Natalia García-Casares et al., "Brain Functional Connectivity Is Modified by a Hypocaloric Mediterranean Diet and Physical Activity in Obese Women," *Nutrients* 9, no. 7 (2017): 685, https://doi.org/10.3390/nu9070685; and Mohammad I. Kawas et al., "Modified Mediterranean Ketogenic Diet Resolves Default Mode Network Connectivity Differences between Adults with Normal and Impaired Cognition," *Alzheimer's & Dementia* 17, no. S1 (2021): e056711, https://doi.org/10.1002/alz.056711. Diet may attenuate the effect of network disruptions and contribute to the modification of dysfunctional connectivity among obese or cognitively impaired individuals.

[75]Considering the activity of the DMN in social interactions, Wanqing Li, Xiaoqin Mai, and Chao Liu, "The Default Mode Network and Social Understanding of Others: What Do Brain Connectivity Studies Tell Us," *Frontiers in Human Neuroscience* 8, no. 74 (2014), https://doi.org/10.3389/fnhum.2014.00074; in internal reflection and contemplation, Immordino-Yang et al., "Rest Is Not Idleness"; and during self-regulation, Kelley et al., "Self-Regulation System."

[76]Todd W. Hall and M. Elizabeth Lewis Hall, *Relational Spirituality: A Psychological-Theological Paradigm for Transformation* (Downers Grove, IL: IVP Academic, 2021).

[77]Skylar J. Brooks et al., "Parental Religiosity Is Associated with Changes in Youth Functional Network Organization and Cognitive Performance in Early Adolescence," *Scientific Reports* 12, no. 17305 (2022): 9, https://doi.org/10.1038/s41598-022-22299-6.

[78]Robert G. Crosby and Erin I. Smith, "Measuring Children's Church-Based Social Support: Development and Initial Validation of the Kids' Church Survey: The Kids' Church Survey," *Social Development* 26, no. 2 (2017): 423–42, https://doi.org/10.1111/SODE.12198; Robert G. Crosby et al., "Trauma-Informed Children's Ministry: A Qualitative Descriptive Study," *Journal of Child & Adolescent Trauma* 14 (2021): 493–505, https://doi.org/10.1007/s40653-020-00334-w; Erin I. Smith and Robert G. Crosby, "Unpacking Religious Affiliation: Exploring Associations between Christian Children's Religious Cultural Context, God Image, and Self-Esteem across Development," *British Journal of Developmental Psychology* 35, no. 1 (2017): 76–90, http://doi.wiley.com/10.1111/bjdp.12156.

[79]Robert G. Crosby et al., "Practices of Supportive Church Children's Ministries: An Exploratory Multilevel Investigation of Church of the Nazarene Congregations in the United States," *Review of Religious Research* 63 (2021): 381–409, https://doi.org/10.1007/s13644-021-00446-1. Although this research did not measure neural activity, evidence from Yang et al. suggests that even mid-conversation pauses can be understood to reflect the engagement of the DMN and the temporary disengagement of the external networks: in Xiao-Fei Yang et al., "Looking Up to Virtue: Averting Gaze Facilitates Moral Construals via Posteromedial Activations," *Social Cognitive and Affective Neuroscience* 13 (2018): 1131–39, https://doi.org/10.1093/scan/nsy081.

[80]Richard J. Foster, *Celebration of Discipline: The Path to Spiritual Growth* (New York: Harper Collins, 1998); and Dallas Willard, *The Spirit of the Disciplines: Understanding How God Changes Lives* (New York: HarperSanFrancisco, 1999).

[81]Joshua J. Knabb, Erin L. Johnson, and Fernando Garzon, "Introduction to the Special Issue: Meditation, Prayer, and Contemplation in the Christian Tradition: Towards the Operationalization and Clinical Application of Christian Practices in Psychotherapy and Counseling," *Journal of Psychology and Christianity* 39, no. 1 (2020): 5–11. The other articles in this issue all explicitly deal with the topic of meditation, prayer, and contemplation.

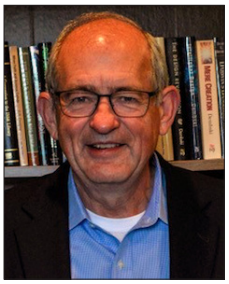
[82]Buckner, "The Brain's Default."

[83]Mark R. McMinn, *The Science of Virtue: Why Positive Psychology Matters to the Church* (Grand Rapids, MI: Brazos Press, 2017), 4–6.

[84]Kelley et al., "Self-Regulation System"; Kevin P. Madore and Anthony D. Wagner, "Multicosts of Multitasking," *Cerebrum: The Dana Forum on Brain Science* (2019), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7075496/; and Eyal Ophir, Clifford Nass, and Anthony D. Wagner, "Cognitive Control in Media Multitaskers," *Proceedings of the National Academy of Sciences of the United States of America* 106, no. 37 (2009): 15583–87, https://www.pnas.org/doi/10.1073/pnas.0903620106.

[85]Erin I. Smith, "The Role of Psychology in Advancing Dialogue between Science and Christianity," *Perspectives on Science and Christian Faith* 72, no. 4 (2020): 212–13, https://www.asa3.org/ASA/PSCF/2020/PSCF12-20Smith.pdf.

[86]James Smith, *You Are What You Love*; and James Smith, *Desiring*.



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Article

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Rethinking Abiogenesis: Part III, Meaning in the Light of Complexity, Information, and Simplification

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This article concludes a three-part series on abiogenesis that suggests meaningful configurations of organic components can arise spontaneously, leading to organisms that successfully survive and reproduce. While the complexity of the disorganized abiotic world makes it appear to some that such a feat of organization would require the nonnatural intervention of an intelligent mind (including but not limited to supernatural intervention), we suggest that careful considerations of thermodynamics and information lead to the plausibility of a natural occurrence. No specific, complete pathway for abiogenesis has yet been identified, but the fundamental processes that enable such a path can be articulated more clearly now than ever before as a result of new and continuing research in multiple disciplines. This concluding article centers on the way in which complex states of molecular organic information can be generated to produce the most meaningful configurations.

Keywords: Abiogenesis, origin of life, information, complexity, simplification, evolution, systems chemistry, natural selection

The quest to understand the origin of life may be as ancient as humanity itself. With little physical evidence to guide understanding, most early cultures evolved narratives of origins that reflected the interaction of a spiritual world with our physical universe.[1] The biblical account of creation forms the basis for the dominant narrative of origins in the western world. The interpretation of that account varies widely from a literal interpretation of a specific English translation to a deeply metaphorical perspective. One particular dichotomy of assumptions about the transition from nonlife to life concerns us here. On the one hand, many are convinced that the biblical account reflects one or more miraculous occurrences that do not conform to any discernible scientific process.[2] On the other hand, many think that God created the universe to enable a natural transition from a nonliving universe to a world teeming with an amazing diversity of species.[3] Scientific observations do not, as yet, provide compelling evidence for irrefutably distinguishing between these two perspectives. While God is certainly capable of using any means of God's choosing for the creation of life, it is the conviction of the authors that it is demonstrably worthwhile to explore plausible naturalistic paths by which God may have enabled the appearance of life from nonlife.

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In Part I, we argued that it may be useful, even important, to perceive the origin of life as a seamlessly continuous (and arguably incomplete) process. This contrasts with a more traditional view that abiogenesis refers to a specific point in time or evolutionary history.[4]

In Part II, we proposed that life may be considered as a simplification of the nonliving universe, such that the beginning of life (abiogenesis) may be usefully perceived as a reduction of complexity from the randomness of the prebiotic world.[5] This stands in sharp contrast to a more typical view of perceiving life as an increase in complexity from simpler molecules. Certainly, the intuitively awesome intricacy of life as we know it is remarkable, especially compared with what seems to some a less interesting, nonliving universe. And yet, the perspective of asking about increasing complexity (e.g., through synthetic chemistry or artificial life) has not yet yielded a plausible, comprehensive pathway from nonlife to life. This difficulty leads some to conclude that a supernatural agent or cause must have been necessary for the appearance of life.[6]

In this Part III, we delve deeper into definitions of information, complexity, and meaning so as to offer more explicit precision about how simplification in the prebiotic world enables the possibility of a natural pathway for abiogenesis.

In the first section of this article, we explore the concepts of complexity and meaning, comparing them with the concept of information. Next, we seek to show that in at least some clear sense(s) of the word, simplification through natural selection is as much an inherent aspect of the evolutionary process as increasing complexity. By turning next to consider abiogenesis explicitly, we conclude by arguing why it may be instructive to consider the importance of simplification in the prebiotic world in the sense of forming a relatively stable and more ordered structure from a disorganized, complicated environment.

The Complicated Concept of Complexity as It Relates to Information and Meaning

There is no single, universal definition of complexity within science,[7] and that important fact is a foundation for the more nuanced ideas we seek to introduce here. Put another way, a range of possible interpretations must be placed into context before careful discussion may proceed. Such discussion can helpfully consider *complexity* in comparison with two related concepts, namely *information* and *meaning*. In what follows, we explain from where we derive the following brief distinctions:

Information is a measure of the uncertainty in any system that can exist in a number of different states. The uncertainty is resolved when the state of the system is determined.[8] The amount of information reflects the number and probabilities of all possible alternative states. This is often called "Shannon information." Unless specified otherwise, in this article, the word "information" will refer to Shannon information.

Complexity refers to the minimum work required to describe a particular state of information.[9] States with a higher diversity of components are more complex than those with lower diversity because the former are more difficult to describe.

Meaning, from the perspective of information theory, is the value or usefulness of a particular state of information.[10] It may, for example, refer to matching a preconceived pattern or blueprint, conveying knowledge or an idea, or causing a particular biological function.[11] Meaning is often determined by an "interpreter" that exhibits the usefulness.[12] This definition of *meaning* overlaps with what, in common usage, we often call "information," (e.g., "Detectives have received information leading to a number of arrests"). This overlap offers ample opportunity for confusion, leading Claude Shannon and Warren Weaver to caution against confusing the two.[13]

To illustrate the definitions given above, their overlap and their differences, let us consider the popular game Wordle.[14] The Wordle website selects a secret five-letter word that the player seeks to determine by a series of guesses. After each guess, the website responds by identifying which letters in the guess occur in the secret word and whether or not they are in the right location. The player wins if the secret word is determined in six or fewer guesses. Wordle helps us illustrate the way in which context is essential to all of the three concepts under consideration (information, complexity, and meaning).

Beginning with *information,* we may determine how much is contained in each secret word of this game. The answer depends on a number of assumptions in setting up the game.

1. Of which language will we use the alphabet (e.g., English, French, Ancient Greek)?
2. Are special symbols allowed (such as accents, hyphens, or spaces)?
3. Can any five-letter sequence be used or must the word exist within a specified dictionary?

In light of these assumptions, it becomes clear that the amount of information depends on the context. In our word game, if we assume that we use the contemporary English alphabet with no special symbols and it need not be a word, then there would exist 26^5 possibilities. The amount of information is 23.5 bits.[15] But if we restrict the combinations of letters to those that comprise a 5-letter word, then there exist only 12,478 possible words[16] and the amount of information is reduced to 13.6 bits. There is less information because of interdependence between the letters. Sequence matters. For example, if the first letter is a "b," then the second letter is most likely a vowel or one of only a few consonants. Many consonants have zero probability of occurring. Because there are fewer possible states, the amount of information decreases as well as the complexity, but the capacity for meaning is maintained or increased. Other changes to our assumptions can significantly change the amount of information. Increases could come from choosing to allow hyphenated words or choosing to recognize the typeface, font size, or font color. Anything that can be different may be employed in an information system. For this reason, context is essential.

Once the context is fixed, it is possible to physically change both the amount and the state of *information*. A physical change in the sequence of the letters in the example of Wordle changes not only the word, or state of information but potentially the amount of information as well. In general, any physical energy flux (i.e., input or output of energy) in a system can modify and increase or decrease information.[17]

Complexity, in contrast, deals with a single, specific state of the system. One of the most common metrics for complexity is "Kolmogorov complexity."[18] This measures the number of bits of the shortest possible lines of code that a universal coding machine (e.g., a Turing machine) would need to describe the state of a system. This is the primary type of complexity used in algorithmic information theory.[19] It can be thought of as measuring the diversity of the specific information states of the system. But Kolmogorov complexity, like information, depends on the assumptions being used. Like information, the complexity of a given sequence of letters decreases if we know ahead of time that the letters must form a word in a specified language, since only a few of the letters may be needed to determine the rest. More generally then, a repetitive sequence is less complex than one that is all random.

Turning to considering *meaning* brings new challenges to thinking clearly about both *information* and *complexity*. In Wordle, the secret word is restricted to the set of words preselected by the author of the game. In contrast to the case of a random set of five letters, relationships between the letters and their sequences are important. If there is a high degree of repetition of letters, not only is the complexity low, but there is less likelihood of having a meaning. A random set of letters with no pattern, on the other hand, will have high complexity while also having a low likelihood of meaning. In the intermediate range where there is some degree of order, the complexity is medium, but the potential for having a meaning is higher.

Warren Weaver, one of the earliest scientists/mathematicians to address complexity, recognized the role of order in complexity in 1947.[20] He suggested a primary distinction between two types of complexity: disorganized complexity and organized complexity. Disorganized complexity occurs wherever a system involves minimal order between components, such as a collection of letters for which there is no particular sequence. Organized complexity occurs wherever the ordering between elements of the system is very important; for example, if those same letters occur in a sequence, such that one ordering produces a word whereas another produces a nonsense anagram of that word, then there is organized complexity.

To measure complexity that accounts for organization within the system, Charles Bennett proposed a related measure called "logical depth."[21] It attempted to quantify the role of meaning, or "message value" as he put it. The logical depth can be thought of as the time required, rather than the minimum size, for a universal computing machine to compute a string

of elements for the Kolmogorov complexity. More recently, Terrence Deacon and Spyridon Koutroufinis sought to offset shortcomings of "logical depth" by proposing a measure of "dynamical depth."[22] They seek to account for nested interacting organization levels rather than just the structural complexity.

When the presence of *meaning*, or message value, is part of the context for considering information, we need to think carefully about what kind of meaning is relevant. Stephen Meyer stresses the importance of distinguishing between meaning that conveys "a piece of knowledge known by a person" versus "a sequence of characters or arrangements of something that produce a specific effect" and that "it is also necessary to distinguish Shannon information from information that performs a function or conveys a meaning."[23] The latter is typically called "specified complex information."

For our discussion of abiogenesis and evolution, the difference between these two aspects of meaning is crucial. While conveying a piece of knowledge requires an intelligent agent as an interpreter, producing a specific effect or function is different. That which enables an organism to survive and reproduce is a self-sustaining interpretation or meaning created between an organism and its environment, for which no intelligent receiver or interpreter is required.[24]

This point may be clarified by comparing the word-game we have been discussing with human genetics. When one player thinks of a five-letter word, they may write it down with pencil and paper, in which case the meaning has been transformed from one medium to another through the agency of an intelligent mind. A dictionary might pass superficially for a non-intelligent agent that validates this meaning, but considered more carefully, it is merely documentation of the abstract relationships to which intelligent minds have previously agreed.

In contrast, the human genome contains a segment of DNA, called a "gene," that codes for a specific protein.[25] A suite of molecular machinery, coordinated by the ribosome, translates this sequence of nucleotides (i.e., the gene) into a corresponding sequence of amino acids, which link together to form a protein. More accurately, the protein is a complex, 3-dimensional shape formed when the linked sequence of amino acids folds up spontaneously, because the shape (of the folded protein) yields both structure and function.[26] Protein sequences with meanings (functions) that tend to help the genome achieve successful replication are, by definition, those which "reward" their corresponding genes to flow forward in time and increase in frequency. Such functions often involve catalyzing specific (bio)chemical reactions to occur faster than they would otherwise. In this sense, we may say that the genome has an embodied meaning to build proteins. But there is no need or process for the meaning of the protein (or genome) to involve matching any predetermined specification. A theologically and philosophically interesting discussion about *meaning* must look far deeper than a limited view of genomes (or proteins) creating meaning: it must instead explore whether and how one might perceive an intelligent **agency** causing and sustaining the fundamental physics of the universe. In the words of Loren Haarsma, in a 1995 letter on behalf of the American Scientific Affiliation to the National Association of Biology Teachers,

> While each of these mechanisms can be modeled as a purely natural process, this does not tell us whether the entire evolutionary process is ultimately supervised or unsupervised. That question goes beyond the realm of science, into philosophy and religion.[27]

To illustrate the difference, we note that some have argued a role for abstract interpretation within the genetic code by which genes are translated into proteins.[28] From the perspective of natural science, here we find nothing more than a straightforward chain of cause and effect. Translation involves the interpretation of a nucleotide gene sequence by molecular machinery (mainly tRNA molecules coordinated by a ribosome) as a set of mini-sequences, each of them 3 nucleotides in length. Each mini-sequence is known as a codon; every possible codon that can be constructed from an "alphabet" of 4 nucleotides ($4^3 = 64$) *means* a specific amino acid, so that the set of possible codons and their meanings together compose an elaborate genetic code.[29] Like the example with an intelligent mind, genetic information is transformed from one physical medium (nucleotides/gene) to another (amino acids/protein). But unlike the example with an intelligent mind, the meaning of the gene and protein sequence requires no abstract interpretation. Abstract interpretations by human researchers may, however, see deeper by moving to other disciplinary perspectives, but in doing so,

they change assumptions as they move to arguments about meaning of the material universe, and they lose any unique need for direct, intelligent agency within molecular biochemistry or life's origins.

To summarize the core concepts from which we now proceed, *information, complexity,* and *meaning* are all contextual and depend on the assumptions and the variables being assessed. Information reflects the uncertainty arising from the number of different possible states of the system while complexity reflects the effort required to describe the structure, relative ordering, and dynamic interaction of a particular state of the system. A particular state of the system may have meaning either by conforming to a predesignated (abstract) state or by causing a specific physical effect.

Complexity and Simplification in the Evolution of Living Organisms

Before turning to consider the origin of life, it is helpful to see first how the concepts of information, complexity, and meaning apply to changes over time in the biological world that we observe today. For this part of the discussion, our focus will be the change in complexity over one generation of a population, from birth until these offspring produce the next generation.

Let the collective set of genomic and epigenomic information of all members of a given generation, g0, be characterized by a reference complexity, c0. Once that population undergoes a reproductive cycle, there will be a new collective set of information of the offspring generation, g1, that is characterized by complexity, c1. Usually, this new set of information will be more complex ($c1 > c0$). Typical causes for this increased complexity include increased population size (since the number of offspring is often greater than the number of parents) and increased genetic diversity (as mutations of all kinds create new variations of genetic material[30]).

By most measures of complexity, more individuals and/or more genetic diversity represent an increase in the total complexity of genomic and epigenomic information of the next generation. This increase is, however, temporary. As the offspring generation, g1, progresses through its life cycle, the effects (changes in function) of different genetic variations become manifest. Members of that population carrying variations which produce functions that are less well adapted to their environments will contribute less, by reproduction, to the next generation: at an extreme, their carriers may die before reproduction. In this way, the complexity of the information of g1 reduces over time, from fertilization until the second offspring generation, g2, is produced ($c1_{\text{at time of reproduction}} < c1_{\text{at time g1 is created}}$). The complexity, c2, of g2 is, again, greater than c1 ($c2_{\text{at time g2 is created}} > c1_{\text{at time of reproduction}}$). Generation 2 undergoes simplification, though, depending on the degree and type of adaptation; the ultimate complexity, c2, at time of reproduction may be greater than that of g1 at time of reproduction ($c2_{\text{at time of reproduction of g2}} > \sim c1_{\text{at time of reproduction of g1}}$).

A detailed example that illustrates this concept is presented in box 1. Within this life cycle, the complexity reduction phase is a simplification through selective elimination, commonly called "natural selection." But in the terminology of information theory, the selection process of simplification is effectively a feedback mechanism that injects meaning into the system. It identifies what genomic information is most capable of persisting in a given environment. Thus, nature itself provides a go/no-go decision on the subset of genomic information (the sequence of genetic chemical structures) which continues to the next reproductive cycle. More broadly, organized complexity may gradually increase by iteration of complexification and simplification. Nature explores a wider and more complex set of configurations in each generation and the competition for resources ("survival of the fittest") results in finding a set that has good persistence.

From within the perspective of the natural sciences, the *meaning* of the sequence and configuration of the genome and epigenome is the ability of the organism to survive and reproduce. This ability reflects the relationship between function and environment. The result of repeatedly iterating a sequence of complexification and simplification can result in an increase in organized complexity. Complexification occurs naturally in the interaction between the environment and the reproducing organisms. Simplification occurs naturally in the ability to survive and reproduce. This is the core process of evolution by natural selection that Charles Darwin proposed in the nineteenth century.

Box 1: Example of Simplification in a Generation of Humans

Consider a generation, g0, consisting of a theoretical population of 10,000 humans, half of which are men and half are women, all of whom remain alive during their reproductive years. This generation comprises 10,000 unique genomes and is characterized by a complexity, c0. There is a spectrum of differences between these genomes and some theoretical reference genome that characterizes the entire population. According to the Population Reference Bureau's 2021 World Population Data Sheet, the global total fertility rate of women was 2.3 births per woman, down from 3.2 in 1990.[1] Assuming a value of 3 for our example, we would expect 15,000 births to occur in this theoretical g0. It is estimated that approximately 30–40% of all conceptions result in miscarriage.[2] Taking 1/3 as an average number, we would expect a total of 22,500 conceptions to have taken place. This means that the 10,000 people in g0 would produce 22,500 fertilized eggs comprising the offspring generation, g1. This set of genomes has greater complexity, $c1_{\text{at time of conception}}$, than that, c0, of the genomes of g0 for two primary reasons. One is the larger number of genomes. The other is that each genome of g1 differs from every other genome in g1 due to crossover in gamete formation and mutations such as SNP's, HGT's, and retroviruses.[3]

It is further estimated that approximately half of the 30–40% miscarriage rate is due to some type of chromosomal abnormality. This most likely corresponds to significant harmful deviations from a viable genomic sequence. The miscarriages of 7,500 fertilized eggs in our example is the first and largest selection process that eliminates the genomes that cannot survive. Following birth, the infant mortality, currently approximately 0.9%, partially reflects genomic structures that are less able to survive. Additional selection occurs through an approximately 10% infertility rate. The population of g1 that is able to reproduce to create the second offspring generation, g2, would be about 13,365. Thus, we have a simplification of the population of g1 from 22,500, $c1_{\text{at time of conception}}$, to 13,365, $c1_{\text{at time of birth}}$. This simplification process produces a set of g1 genomes that may contain individuals with more complexity than those of g0, in which the more complex changes enable better survival in the slightly modified environment of g1 compared with g0.

For humans, as with most species that reproduce sexually, there is an additional cycle of complexification and simplification in the pre-fertilization phase. On average, a man produces on the order of a trillion (10^{12}) sperm in his lifetime. Each sperm contains a gamete with a single set of chromosomes formed through meiosis. A woman is born with about a million (10^6) ovarian follicles that potentially could become mature eggs, of which there are ultimately about 500 in a lifetime. Each follicle contains a gamete that similarly has a single set of chromosomes formed through meiosis. The set of sperm from each man and follicles from each woman comprises a vast complexification from their respective genomic sequences. The dominant process of simplification is the selection of which sperm and which egg will mature and be able, given the opportunity, to produce a fertilized egg. This means that each fertilized egg is selected from about 10^{18} potential combinations, each with a genomic sequence that did not exist before and, unless selected, will never occur again. While the numbers are different for each species, the process is essentially the same—a combinatorial complexification with mutations from which a very few are selected; this is effectively a simplification that can be expressed by the relation $c1_{\text{potential gamete combinations}} >> c1_{\text{fertilization attempts}} >> c1_{\text{at time of conception}} >> c1_{\text{at time of birth}} > c1_{\text{at time of reproduction}}$. This simplification of g1 leads to a $c1_{\text{at time of reproduction}}$ that may be greater than the $c0_{\text{at time of reproduction}}$ of g0.

Notes

[1]Population Reference Bureau, "Impact of COVID-19 Pandemic on Global Birth and Death Rates Unclear, with Many Countries Lacking Reliable Data," August 17, 2021, accessed November 16, 2021, https://www.prb.org/news/2021-world-population-data-sheet-released/.

[2]Department of Gynecology and Obstetrics, The Johns Hopkins University School of Medicine, Baltimore, Maryland, *The Johns Hopkins Manual of Gynecology and Obstetrics,* 4th edition (New York: Lippincott Williams & Wilkins, 2012), 438–39.

[3]Ultimately the source of all genetic variation is mutation. Although introductory textbooks might distinguish genetic crossover (if dealing with sexual reproduction between diploid organisms that undergo meiosis) from mutations (e.g., Single Nucleotide Polymorphisms, insertions, and deletions) and even exotic events which involve the addition or deletion of genetic letters through horizontal gene transfer or the action of retroviruses, none of these would introduce new information had not mutation acted somewhere in their evolutionary history.

Life as Simplification of the Nonliving Universe

Having first introduced information, complexity, and meaning, then discussed how these concepts apply to evolution by natural selection, we now turn to asking how far this framework of understanding can go in describing a plausible pathway to the emergence of life within a nonliving universe: abiogenesis.

The Russian physical chemist Ilya Prigogine pioneered a field of study in statistical mechanics, identifying a category of systems he called "dissipative structures." Prigogine received the 1977 Nobel Prize in Chemistry[31] for his work on these systems which are thermodynamic systems that exist in a state far from equilibrium.[32] For example, a harbor on the ocean is a body of water in equilibrium at sea level. A lake in the mountains is far from equilibrium due to its gravitational potential energy. In the language of thermodynamics, this lake would be called "a metastable state" because it is stable, but at a higher state of energy than the global equilibrium (sea level). When containment of the lake is breached, water rushes toward sea level, exhibiting behavior very different from that of water in equilibrium. As long as meteorological conditions sustain a cycle of ocean evaporation and condensation in the mountains to replenish the lake, the system of rushing water, converting potential energy to kinetic energy, will be a steady state of flow which can be called "a dissipative structure." Prigogine's insight was that there exist physical dissipative systems far from equilibrium that self-organize into metastable states which may exhibit lower entropy.

In his chapters on thermodynamics in *The Mystery of Life's Origin*, Walter Bradley's critique was that nothing here could speak meaningfully to life's origins because dissipative systems fail to account for the configurational work needed to assemble life.[33] Work is needed to bring order from chaos: to find, from within a vast entropy, a specific configuration of molecules that reproduces and evolves. Bradley's specific focus was on the component organic molecules that must be assembled in a particular configuration (sequence) out of nearly countless possibilities.

In 2022, we may address the criticism by placing Prigogine's ideas into an interdisciplinary sandwich formed by subsequent work in two related (but distinguishable) subfields (fig. 1). On one side lie developments in non-equilibrium physics; on the other side lie developments in systems chemistry. Combined with the foundations laid by Prigogine, this body of theory argues for the relevance of exactly the sort of experiments in organic synthetic chemistry that we find currently at the leading edge of abiogenesis research.

From physics, the pioneering work of Jeremy England shows how thermodynamics allows nonliving systems to transition to lower states of entropy in the presence of an energy source: a cyclical driving force can modify a system in remarkable ways that simply cannot happen at equilibrium. In more precise, technical terms, non-equilibrium thermodynamics can enable an open system (i.e., one that is absorbing a flux of energy) to move to any of a large number of metastable states, some of which are likely to have lower entropy.[34] Metastable states with lower entropy might well have a shorter lifetime,

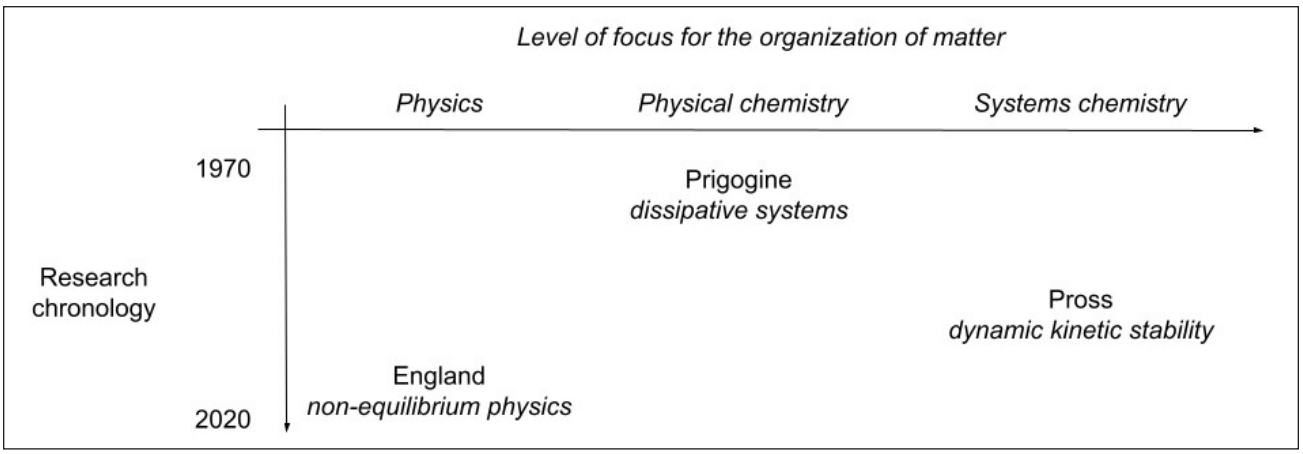

Figure 1. Three overlapping areas of research have emerged since the late twentieth century to explain how matter can self-organize into states which exhibit organized complexity and lower entropy.

but they may also modify the system's response to the incoming energy flux. Modifications which dissipate energy more efficiently can stabilize the lower entropy state. Writing about all this for a lay audience, England uses his Jewish faith to notice and use the metaphor of the bush which Moses saw burning, without becoming consumed: contrary to our lived experience, within this vision it is the very act of burning which stabilizes the persistence of the bush. Indeed, the centrality of this metaphor to his work comes across from the title of his book: *Every Life Is on Fire*.

In more precise, technical language England's research team has studied simple physical systems to which an oscillating energy source is applied. One study modeled 20 idealized particles that make and break catch-bond springs[35] with each other,[36] another simulated spin glasses responding to time-driven external fields.[37] In all cases, the system showed the capability (which may appear to some as *agency*) to restructure itself into a new steady state that alters how further energy is received. The spectrum of work absorption can shift to either increased or decreased energy absorption, and the direction of this shift depends upon the specific parameters of the driving force relative to the spring characteristics. Of particular interest, when a large concentration of elements is repeatedly exposed to cyclical energy sources, it will find the most efficient configurations for maintaining metastable states. In other words, a simplification process will eliminate those states that are least stable and select a state that persists in the presence of that driving force.

Complementing these foundations in physics we find the systems chemistry of Addy Pross, and specifically the concept of "dynamic kinetic stability" (DKS) by which non-equilibrium, open systems can sustain metastable states.[38] Living organisms are metastable systems that are more efficient than nonliving metastable systems in utilizing energy flux to sustain their existence, and are therefore favored to develop. Pross illustrated DKS with the example of a river. A river is stable even though the water molecules that compose a river are constantly moving and changing (no man can cross the same river twice!). The river has dynamic kinetic stability. As described previously, it is a metastable, non-equilibrium system that is sustained by energy flux. Warmed by the sun, water in the ocean evaporates. Winds convey the water vapor to higher land where the cooler air causes the water to condense as rainfall in mountainous regions. Gravity compels the water to find its way back to the ocean. Before any riverbed existed, the paths for water to flow down were varied and complex. Those paths that were most favorable underwent the greatest erosion, gradually increasing their ability to facilitate the flow of water. Eventually the most favorable path became a riverbed, establishing a river with dynamic kinetic stability as a result of a process of simplification. (By the way, there was no sense in which an intelligent agent was required to identify this optimal or near optimal path to the ocean).

Pross argues that while natural selection as we know it in the biological world cannot act in the prebiotic world, there is an equivalent process of "kinetic selection." He points to work by Sol Spiegelman[39] and Gerald Joyce[40] to show how competitive exclusion operates in the chemical world of organic systems just as it does in natural selection. Building on that perspective, Pross goes on to show that the biological concept of fitness is the same principle as DKS in the prebiotic world. This is consistent with our perspective on continuity in the origin of life. If one looks backward from a biological perspective, it is hard to see reproduction with variation and survival of the fittest occurring in the prebiotic world. But if one looks forward from the competitive world of organic chemical reactions, the principles of kinetic selection and DKS can be seen as the basis for natural selection and fitness in the far more complex world of living organisms.

But back to our major theme: we might re-express the shifts to new steady states of energy absorption shown by England and colleagues, in the language of systems chemistry, as examples of dynamic kinetic stability. Thus, recent physics tells us that nonliving systems can transition into lower states of entropy in the presence of an energy source, particularly a cyclical driving force. Physical chemistry tells us that low entropy states can exist as stable states far from equilibrium so long as they dissipate energy into entropy. Systems chemistry tells us that non-equilibrium, open systems can be sustained in metastable states. From this theoretical framework in physics and chemistry (fig. 1), we finally may turn to consider explicitly those studying the sort of organic synthetic chemistry which produces molecular biochemistry.

Turning to Abiogenesis

The research community tackling abiogenesis comprises many different approaches and disciplines. One useful way to sketch a map of this sprawling frontier is to distinguish those who choose to work "top down" and those who work "bottom up."[41] Here "bottom up" research focuses on the chemistry and physics of the nonliving universe, often asking what processes and conditions are conducive to forming the two classes of biological polymer that are central to life as we know it: nucleic acid and protein. "Top down" research comprises those who work backwards toward the prebiotic world from these central facts of "modern" (post-LUCA) biology: genes, proteins, and the molecular machinery that translates the former into the latter. Within this schema, at the interface where top down meets bottom up, lies a subcommunity of researchers who have explored for decades the extent to which "wet/dry cycles" can cause monomeric building blocks—amino acids and nucleotides—to join together into polymers: RNA and protein (DNA is thought to have arisen later as a derivative of RNA).

Wet/dry cycles, as the name implies, refer to an environment in which watery conditions alternate with periods of evaporation/drying. In various incarnations,[42] this environment has been pictured as the shoreline of a primordial ocean, streams that flow ephemerally after rain, springs or pools of water with drying edges, or even their opposite counterpart of geothermal fields where water sinks into the crust and dries as it encounters ever hotter depths.[43] What unites all such specific instances is that the organic chemistry of an aqueous solution shifts back and forth with the different organic chemistry that takes place as water is removed from the system.

The regime of wet/dry cycles was first conceived as one conducive to the formation of biopolymers simply because the chemical reaction which forms both nucleic acids from nucleotides, and proteins from amino acids, involves the removal of water molecules (see fig. 2).[44] Simply put, the relevant monomers form under a range of different chemistries and pathways within an aqueous solution, and the subsequent removal of water favors these monomers further reacting together to form polymers.

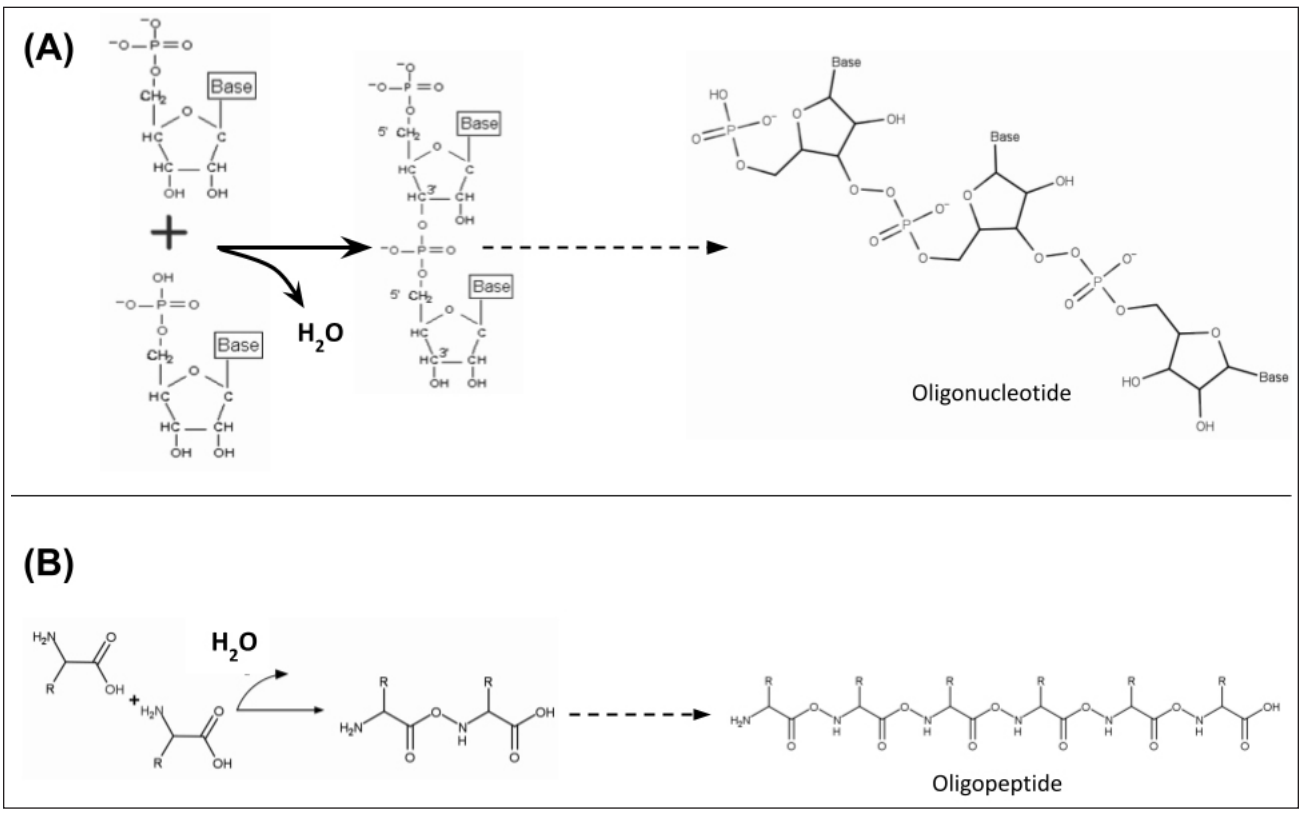

Figure 2. The chemical reactions by which life's chemical building blocks form into polymers involve the removal of water molecules. **(A)** nucheotides link together through a phosphodiester linkage into sequences of RNA; **(B)** amino acids link together through peptide bonds to form proteins.

As such, the concept of wet/dry cycling has been applied over the decades to study every aspect of biopolymer formation, from the "dehydration condensation" reaction at the heart of polymerization,[45] to processes involving spontaneous self-purification of the resulting polymers[46]—it even offers another pathway towards monomer formation.[47] But from an initial motivation of chemistry (seek a process that favors the removal of water molecules) it is interesting to note how pioneers of this approach have increasingly come to absorb and reflect the maturing physics and chemistry of non-equilibrium systems. We may, for example, illustrate how seamlessly and directly wet/dry cycling research meshes with all we have written about how meaningful complexity is generated. To do so, let us consider the specific case study of Bruce Damer and David Deamer who have explored iterative wet/dry cycles around pools fed by hot springs.[48] They present the rationale for their approach as follows.

> Energy-driven cycles are central to life's ability to maintain itself in a far-from-equilibrium state against the trend toward ever increasing entropy. Therefore, it is reasonable to consider the possibility that life's origin also depended on cycles … Significantly, cycling also drives a series of natural experiments that undergo combinatorial selection in the form of encapsulated polymers.[49]

They go on to examine in detail a variety of energy-driven cycles. One is the distillation process resulting from evaporation and condensation. Another is the alternate drying and hydration of pools. They describe the process this way:

> Hydrothermal pools undergo wet-dry cycles resulting from precipitation and fluctuating water levels … Polymers are synthesized by condensation reactions occurring within these dried films … During the hydration phase, vesicles bud off, encapsulating systems of polymers to form protocells … This process generates random sets of polymers captured in vesicles to form vast numbers of protocells. Frequent cycling of these populations initiates the combinatorial selection process that drives chemical evolution and enables the emergence of ever more robust protocells. As the protocells continue to undergo the stresses of cycling, most will be disrupted, their components leaking out or dispersing through disrupted membranes, but a rare few are likely to contain polymers that enhance their survival … The products of selection that cycling systems generate can lead to the stepwise emergence of increasingly functional polymers …"[50]

Note that the "combinatorial selection process" to which they refer is directly equivalent to the configurational entropy work that Walter Bradley identified as missing from the body of thought developed by Prigogine.

It remains to be seen how fruitful Damer and Deamer's particular scenario will be in showing the plausibility of abiogenesis. Other researchers explore how life began with the formation of RNA,[51] or RNA fragments,[52] or RNA-like fragments.[53] We, along with Damer and Deamer, would argue however that this gradual dissipation over time of strong claims for "RNA first" within the scientific literature has much further to go, and would look for energy flux to produce a sequence of chemistries that lead onward toward RNA. Rather than RNA first, we would hypothesize RNA itself as an evolutionary outcome. For the purposes of this manuscript, it matters little. Whichever molecule or starting point is considered, a perceived increase in complexity comes only from limiting one's focus to the evolving genetic content. But genetic, hereditary material is changing over time in response to the environment, and once we broaden our vision to embrace this broader system, we can perceive the genetic material as a simplified representation of the environment. In this light, the work of Damer and Deamer illustrates how some of the earliest steps might have involved a drying, aqueous environment favoring monomers to join together. A dimer looks more complex than two monomers, but is (from our perspective) a simplified, coded reflection of the environment.

Indeed, the words of Damer and Deamer express, in a different disciplinary language, the ideas of non-equilibrium physics from England. We might, for example, re-express Damer and Deamer's ideas as suggesting that energy flux from various sources, such as the cyclical driving force from the sun, seasons, tides, etc., provides the iterative complexification/simplification process that is inherent in the reproduction with variation/natural selection cycle of true biological evolution. In non-equilibrium systems, an increase in energy enables the system to explore a complex set of states with higher energy, many of which may have lower entropy. A dissipation in energy allows the system to settle into

a metastable state which may be a lower entropy simplification from the higher energy complexity. Those metastable states that are capable of persisting (Pross's DKS) modulate the system response to the driving force (England's non-equilibrium physics), and thereby are those which evolve into primitive precursors of life. The local environment provides the information necessary to guide which polymer sequences persist and multiply. This has created the specified complexity we find in gene sequences. The gene sequence is an encoding of the environment, and the encoding is simpler than the full environment in all its dimensions. As successive rounds of selection proceed, the encoding may grow in scope but always as a fraction of the information which it now reflects. There is no need for an intelligent interpreter at any point.

Conclusion

Within this series on "Rethinking Abiogenesis," we have described ideas traditionally presented from a perspective and language of evolutionary biology in the different disciplinary language of information and complexity theory, in order to show how they integrate in a fully consistent, broader framework of scientific research, including the leading edge of abiogenesis research.

Part I of this series on abiogenesis emphasized the continuity in time of the transition from nonlife to life.[54] That continuity is exemplified in our inability to offer a clear demarcation between nonlife and life. Part II expanded that view to consider continuity in space with a close connection between life and the external environment.[55] It was suggested that this connection is helpful to perceive life as simplification, whereby the complexity inherent to an environment is incorporated over time into a biological structure that is increasingly robust within the environment at that time. In this sense, life is a reflection of its environment—and reflections contain less information than that which they reflect.

Here in Part III, by considering carefully the definition of complexity, we discussed in detail the cyclical process of complexification and simplification that produces this reflection. The prebiotic world is high in random, disorganized information with a wide diversity of elements and molecules, both organic and inorganic. Given an environment with multiple high-energy driving forces (whether incoming radiation from the sun on a prebiotic shoreline, or dissipation of interior planetary energy from a hydrothermal vent), a process of self-organization can occur that is effectively one of simplification. Configurations that are simpler and more orderly than the random environment are possible when they modify the system response to the energy flux. Configurations that are more stable have an enduring existence (persistence) that forms the basis for further cycles of complexification and simplification. This can be perceived as a forerunner to the process of reproduction with heritable variation that is ubiquitous to evolution by natural selection, as science currently understands that phrase within biology.

Implicitly, this perspective suggests that abiogenesis should not be sought in the immediate, spontaneous assembly of structures seen within modern life, but rather, in the process which led to such structures over time. In this explicit sense, we suggest that for research into the origins of life, it may be instructive to consider the importance of simplification in the prebiotic world in the sense of forming a relatively stable and more ordered structure from a highly random environment.

Our account of the prominent role of a cycle of complexification and simplification in abiogenesis claims no novel process or mechanism. Rather, it uses the language of information and complexity theory to describe the familiar concept of differential reproductive success in evolutionary theory. While the challenge of understanding abiogenesis remains far from being resolved, we suggest that this account teaches us that a naturalistic origin of life cannot be ruled out and merits further study. We suggest that readers of this journal recognize that the mainstream scientific community studying the origin of life pursues naturalistic abiogenesis, not primarily because of a bias against supernatural intervention, but because of its potential plausibility. ☼

Acknowledgment

We gratefully acknowledge the helpful and thoughtful suggestions by two reviewers and are grateful to ASA member Larry Funck for pointing us to the work of Addy Pross.

Notes

[1]Philip Freund, *Myths of Creation* (New York: Washington Square Press, 1965).

[2]Several examples include the following: Young-Earth Creationism—Dr. Terry Mortenson, "Young-Earth Creationist View Summarized and Defended," in *Answers in Depth*, February 16, 2011, https://answersingenesis.org/creationism/young-earth/young-earth-creationist-view-summarized-and-defended/; Reasons to Believe Model (aka Old Earth Creationism or Progressive Creationism)—Hugh Ross, "Summary of Reasons to Believe's Testable Creation Model," Reasons to Believe, updated March 1, 2022, https://reasons.org/explore/publications/articles/summary-of-reasons-to-believes-testable-creation-model-1; and Intelligent Design—"What Is Intelligent Design?," accessed January 16, 2023, https://intelligentdesign.org/whatisid/.

[3]Evolutionary Creation aka Theistic Evolution—https://biologos.org/common-questions/what-is-evolutionary-creation.

[4]Emily Boring, J. B. Stump, and Stephen Freeland, "Rethinking Abiogenesis: Part 1, Continuity of Life through Time," *Perspectives on Science and Christian Faith* 72, no. 1 (2020): 25–35, https://www.asa3.org/ASA/PSCF/2020/PSCF3-20BoringStumpFreeland.pdf.

[5]Emily Boring, Randy Isaac, and Stephen Freeland, "Rethinking Abiogenesis: Part II, Life as a Simplification of the Nonliving Universe," *PSCF* 73, no. 2 (2021): 100–113, https://www.asa3.org/ASA/PSCF/2021/PSCF6-21BoringIsaacFreeland.pdf.

[6]In a 2010 survey of American Scientific Affiliation members, while 60.2% accepted compelling evidence of evolutionary development for all life from a common ancestral form, only 39.6% accepted a form of abiogenesis. "ASA Survey on Origins: Final Results June 1, 2010," https://cdn.ymaws.com/network.asa3.org/resource/resmgr/OriginsResults.pdf.

[7]Charles H. Bennett stated, "… the problem of defining complexity is itself complex, and there are many satisfactory definitions of different kinds of complexity" in "Complexity in the Universe," in *Physical Origins of Time Asymmetry,* ed. J. J. Halliwell, J. Pérez-Mercader, and W. H. Zurek (Cambridge, UK: Cambridge University Press, 1996), 33–46.

[8]Claude Shannon, "A Mathematical Theory of Communication," in *The Bell System Technical Journal* 27, no. 3 (July 1948): 379–423, https://doi.org/10.1002/j.1538-7305.1948.tb01338.x.

[9]Called Kolmogorov-Solomonoff-Chaitin complexity, this definition can be traced back to A. N. Kolmogoroff, "On Tables of Random Numbers," *Theoretical Computer Science* 207, no. 2 (November 6, 1998): 387–95, https://doi.org/10.1016/S0304-3975(98)00075-9, which is a reprint of Kolmogorov's original Russian paper in 1960.

[10]Charles H. Bennett, "Logical Depth and Physical Complexity," in *The Universal Turing Machine – A Half-Century Survey,* ed. Rolf Herken (New York: Oxford University Press, 1988), 227–57.

[11]Francis Crick, "On Protein Synthesis," in *Symposia of the Society of Experimental Biology* 12 (Cambridge, UK: Cambridge University Press, 1958), 138–63; and Sahotra Sarkar, "Decoding 'Coding': Information and DNA," *BioScience* 46, no. 11 (1996): 857–64, https://doi.org/10.2307/1312971.

[12]Peter R. Wills, "Genetic Information, Physical Interpreters and Thermodynamics; The Material-Informatic Basis of Biosemiosis," *Biosemiotics* 7, no. 1 (2014): 141–65, https://doi.org/10.1007/s12304-013-9196-2.

[13]Claude Shannon and Warren Weaver, *The Mathematical Theory of Communication* (Urbana, IL: University of Illinois Press, 1949), 8.

[14]In 2021, Josh Wardle introduced a word game called Wordle, now owned by the *New York Times,* https://nytimeswordle.io/. It is similar to games like MasterMind and Bulls and Cows in the information sense.

[15]The equation $I = -\sum_{i=1}^{i=N} p_i \log_2 p_i$ is for the amount of information where N is the number of states in which a system can be, p_i is the probability that the system is in state i, and I is given in number of bits, from Shannon and Weaver, *The Mathematical Theory of Communication*.

[16]List of All Five Letter Words, accessed August 20, 2022, https://www.bestwordlist.com/5letterwords.htm. This number depends on the specific dictionary used and the extent to which uncommon words are excluded.

[17]Here, and throughout the discussion that follows, we use the word "system" to refer to any collection of objects that comprises focus of attention, from atoms to individuals within a population. Every possible physical state of a system, including its very existence, constitutes information, but we can choose to confine our usage and analysis to a much more convenient subset of possible states.

[18]Peter Grünwald and Paul Vitányi, "Shannon Information and Kolmogorov Complexity," arXiv:cs/0410002v1, August 8, 2005, https://arxiv.org/pdf/cs/0410002.pdf; https://arxiv.org/abs/cs/0410002; https://doi.org/10.48550/arXiv.cs/0410002.

[19]Ray Solomonoff, *A Preliminary Report on a General Theory of Inductive Inference* (US Air Force, Office of Scientific Research, February 4, 1960), https://std.com/~rjs/rayfeb60.pdf. Revision published November 1960, http://raysolomonoff.com/publications/z138.pdf.

[20]Warren Weaver suggested that the two main types of complexity were disorganized and organized complexity. Warren Weaver, "Science and Complexity," *American Scientist* 36, no. 4 (1948): 536–44, https://www.jstor.org/stable/27826254.

[21]Charles H. Bennett, "Information, Dissipation, and the Definition of Organization" and "Dissipation, Information, Computational Complexity and the Definition of Organization," in *Emerging Syntheses in Science*, ed. David Pines (Santa Fe, NM: The Santa Fe Institute Press, 1985), 297–313.

[22]Terrence Deacon and Spyridon Koutroufinis, "Complexity and Dynamical Depth," *Information* 5, no. 3 (2014): 404–23, https://doi.org/10.3390/info5030404.

[23]Stephen C. Meyer, *Signature in the Cell: DNA and the Evidence for Intelligent Design* (New York: HarperOne, 2009), 91.

[24]Randy Isaac, "The Significance of *The Mystery of Life's Origin*," *Perspectives on Science and Christian Faith* 73, no. 3 (2021): 158–62, https://www.asa3.org/ASA/PSCF/2021/PSCF9-21Isaac.pdf.

[25]George W. Beadle, Edward L. Tatum, and Joshua Lederberg, The Nobel Prize in Physiology or Medicine 1958, https://www.nobelprize.org/prizes/medicine/1958/summary/. See also George W. Beadle and Edward L. Tatum, "Genetic Control of Biochemical Reactions in Neurospora," *Proceedings of the National Academy of Sciences* 27, no. 11 (1941): 499–506, https://doi.org/10.1073/pnas.27.11.499.

[26]Christian B. Anfinsen, Stanford Moore, and William H. Stein, The Nobel Prize in Chemistry 1972, https://www.nobelprize.org/prizes/chemistry/1972/summary/. See

also Christian B. Anfinsen, "Principles That Govern the Folding of Protein Chains," *Science* 181, no. 4096 (1973): 223–30, https://doi.org/10.1126/science.181.4096.223.

[27]Loren Haarsma, "Letter to the National Association of Biology Teachers," November 22, 1996, https://www.asa3.org/ASA/resources/Haarsma1996.pdf.

[28]Meyer, *Signature in the Cell*, 91.

[29]Har Gobind Khorana, The Nobel Prize in Physiology or Medicine 1968, https://www.nobelprize.org/prizes/medicine/1968/summary/.

[30]Ultimately the source of all genetic variation is mutation. Although introductory textbooks might distinguish genetic crossover (if dealing with sexual reproduction between diploid organisms that undergo meiosis) from mutations (single nucleotide polymorphisms, insertions and deletions) and even exotic events which involve the addition or deletion of genetic letters through horizontal gene transfers or the action of retroviruses, none of these would introduce new information had not mutation acted somewhere in their evolutionary history.

[31]Ilya Prigogine—Facts, https://www.nobelprize.org/prizes/chemistry/1977/prigogine/facts/.

[32]See some of his work in Ilya Prigogine and Isabelle Stengers, *Order out of Chaos: Man's New Dialogue with Nature* (Toronto, ON: Bantam Books Canada, 1984); Gregoire Nicolis and Ilya Prigogine, *Exploring Complexity* (New York: W. H. Freeman and Company, St. Martin's Press, 1989); Gregoire Nicolis and Ilya Prigogine, *Self-Organization in Nonequilibrium Systems: From Dissipative Structures to Order through Fluctuations* (Hoboken, NJ: John Wiley & Sons, 1977); and William C. Schieve and Peter M. Allen, editors, *Self-Organization and Dissipative Structures: Applications in the Physical and Social Sciences* (Austin, TX: University of Texas Press, 1982).

[33]Charles Thaxton, Walter Bradley, and Roger Olsen, *The Mystery of Life's Origin: Reassessing Current Theories* (New York: Philosophical Library, 1984).

[34]Jeremy England, *Every Life Is on Fire: How Thermodynamics Explains the Origins of Living Things* (New York: Basic Books, 2020).

[35]Catch-bond springs have increased bond lifetime when mechanically stretched. See Micah Dembo et al., "The Reaction-Limited Kinetics of Membrane-to-Surface Adhesion and Detachment," *Proceedings of the Royal Society of London Series B Biological Sciences* 234, no. 1274 (1988): 55–83, https://doi.org/10.1098/rspb.1988.0038; and Yuriy V. Pereverzev et al., "The Two-Pathway Model for the Catch-Slip Transition in Biological Adhesion," *Biophysical Journal* 89, no. 3 (2005): 1446–54, https://doi.org/10.1529/biophysj.105.062158.

[36]Tal Kachman, Jeremy A. Owen, and Jeremy L. England, "Self-Organized Resonance during Search of a Diverse Chemical Space," *Physical Review Letters* 119, no. 3 (2017): 038001, https://doi.org/10.1103/PhysRevLett.119.038001.

[37]Jacob M. Gold and Jeremy L. England, "Self-Organized Novelty Detection in Driven Spin Glasses," arXiv:1911.07216v1, November 17, 2019, https://doi.org/10.48550/arXiv.1911.07216.

[38]Addy Pross, *What Is Life? How Chemistry Becomes Biology* (Oxford, UK: Oxford University Press, 2012), chapter 7.

[39]D. R. Mills, R. L. Peterson, and S. Spiegelman, "An Extracellular Darwinian Experiment with a Self-Duplicating Nucleic Acid Molecule," *PNAS* 58, no. 1 (July 1, 1967): 217–24, https://doi.org/10.1073/pnas.58.1.217.

[40]Sarah B. Voytek and Gerald F. Joyce, "Niche Partitioning in the Coevolution of 2 Distinct RNA Enzymes," in *PNAS* 106, no. 19 (May 12, 2009): 7780–85, https://doi.org/10.1073/pnas.0903397106.

[41]H. James Cleaves, *The Origins of Life: A Review of Scientific Inquiry* (West Conshohocken, PA: John Templeton Foundation, 2020), https://www.templeton.org/wp-content/uploads/2021/07/JTF_Origins_of_Life_Final.pdf.

[42]N. Lahav and D. H. White, "A Possible Role of Fluctuating Clay-Water Systems in the Production of Ordered Prebiotic Oligomers," *Journal of Molecular Evolution* 16, no. 1 (September 1980): 11–21, https://doi.org/10.1007/BF01732066.

[43]Thomas D. Campbell et al., "Prebiotic Condensation through Wet-Dry Cycling Regulated by Deliquescence," *Nature Communications* 10 (2019): article number 4508, https://doi.org/10.1038/s41467-019-11834-1.

[44]N. Lahav and S. Chang, "The Possible Role of Solid Surface Area in Condensation Reactions during Chemical Evolution: Reevaluation," *Journal of Molecular Evolution* 8, no. 4 (1976): 357–80, https://doi.org/10.1007/BF01739261.

[45]Ben K. D. Pearce et al., "Origin of the RNA World: The Fate of Nucleobases in Warm Little Ponds," *Proceedings of the National Academy of Sciences USA* 114, no. 43 (2017): 11327–32, https://doi.org/10.1073/pnas.1710339114.

[46]Jay G. Forsythe et al., "Ester-Mediated Amide Bond Formation Driven by Wet-Dry Cycles: A Possible Path to Polypeptides on the Prebiotic Earth," *Angewandte Chemie* 54, no. 34 (2015): 9871–75, https://doi.org/10.1002/anie.201503792.

[47]Sidney Becker et al., "Wet-dry Cycles Enable the Parallel Origin of Canonical and Non-Canonical Nucleosides by Continuous Synthesis," *Nature Communications* 9 (2018): article 163, https://doi.org/10.1038/s41467-017-02639-1.

[48]Bruce Damer and David Deamer, "The Hot Spring Hypothesis for an Origin of Life," *Astrobiology* 20, no. 4 (2020): 429–52, https://www.liebertpub.com/doi/10.1089/ast.2019.2045.

[49]Ibid., 435–36.

[50]Ibid., 441.

[51]Michael P. Robertson and Gerald F. Joyce, "The Origins of the RNA World," *Cold Spring Harbor Perspectives in Biology* 4, no. 5 (2012): article 003608, https://doi.org/10.1101/cshperspect.a003608.

[52]Paul G. Higgs and Niles Lehman, "The RNA World: Molecular Cooperation at the Origins of Life," *Nature Reviews Genetics* 16, no. 1 (2015): 7–17, https://doi.org/10.1038/nrg3841.

[53]Nicholas V. Hud et al., "The Origin of RNA and 'My Grandfather's Axe,'" *Chemistry & Biology* 20, no. 4 (Apr 18 2013): 466–74, https://doi.org/10.1016/j.chembiol.2013.03.012.

[54]Boring, Stump, and Freeland, "Rethinking Abiogenesis: Part 1, Continuity of Life through Time."

[55]Boring, Isaac, and Freeland, "Rethinking Abiogenesis: Part II, Life as a Simplification of the Nonliving Universe."

Tyler D. Scott

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A Survey of Science/Theology Paradigms among Students at a College in the Young-Earth or Old-Earth Creationist Tradition

Tyler D. Scott

I report and analyze the administration of a survey investigating students' beliefs about the relationship between science and theology at a college in the young-earth or old-earth creationist tradition. Using a previously established survey, science-theology paradigms were identified. With 221 responses, there was enough statistical power to identify some links between the science-theology paradigms and other beliefs in areas of epistemology of science, theology, and preferred model of creation or evolution. Results showed that these paradigms are often interconnected, not allowing for tidy classifications of students' beliefs about faith and science. Results suggest that students who are more religious and know more science are more likely to match with at least one science-theology paradigm. And, those with more constructivist epistemological views on the nature of science are more likely to view science and Christian faith in harmony.

Keywords: science-theology paradigms, Christian college students, epistemology, theology, creation, evolution, miracles

The relationship between Christian beliefs and science has been an area of interest to a broad range of scholars. Since Charles Darwin, focus has often been on conflict. John William Draper and Andrew Dickson White are often cited as the archetype of the conflict thesis. Some research undermines this idea though, finding that large numbers of scientists, students, and the general population do not operate under the conflict thesis.[1] In one interesting paper, Timothy O'Brien and Shiri Noy found that a "Post-Secular" population of Americans were more religious while also more knowledgeable about and positive toward science than the "Traditional" population.[2] For another good summary of the shortcomings of a simplistic conflict thesis, see Pablo de Felipe and Malcolm Jeeves and references therein.[3]

However, much of current research tends to focus on Americans' acceptance or rejection of biological evolution. Some results have shown that more knowledge of evolutionary theory specifically and science in general leads to higher acceptance of evolution.[4] Leslie Rissler et al. also found that while science knowledge (and being a science major) was predictive of evolution acceptance, religiosity was a more significant factor predicting acceptance or rejection of evolution than educational background.[5] Higher religiosity was correlated to greater rejection of evolution. In that study, religiosity was measured by frequency of religious service attendance and by items from the

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Pew Religious Landscape Study.[6] This result might suggest that rumors of the death of the conflict thesis could be exaggerated.

Among those with insights into the relationship between Christian faith and science, Ian Barbour is probably among the most recognized. He has famously described four views on the relationship between religion and science.[7] While one view is that of conflict, the other views of independence, dialogue, and integration offer alternatives. One of Barbour's types of conflict is "Biblical Literalism," which includes young-earth creationism (YEC) and at least some forms of old-earth creationism (OEC) and intelligent design. The problem is that many young- and old-earth creationists and intelligent design advocates would reject the label of conflict, choosing dialogue or integration instead. Perhaps John Hedley Brooke is correct to say, "There is no such thing as *the* relationship between science and religion. It is what different individuals and communities have made of it in a plethora of different contexts."[8]

The current study is based on the work of Michael Tenneson, David Bundrick, and Matthew Stanford.[9] From Christian literature, including Barbour, Bundrick developed a survey instrument that identified five paradigms labeled (1) Conflict: Science over Theology, (2) Conflict: Theology over Science, (3) Compartmentalism, (4) Complementarism, and (5) Concordism.[10] That work was further developed into the form used by Tenneson, Bundrick, and Stanford[11] and by the current study.

In the first paradigm, Conflict: Science over Theology, both science and theology make claims about the same reality, and science should take precedence whenever those claims conflict. Paradigm 2, Conflict: Theology over Science, is similar in that it sees science and theology making claims about the same reality, but it views the theological claims as preferable. Paradigm 3 is called Compartmentalism. Similar to the non-overlapping magisteria or independence viewpoints described by Barbour,[12] this paradigm views science and theology as separate ways of knowing without overlap. Paradigm 4, Complementarism, recognizes that science and theology describe the same reality. However, they focus on different aspects of reality and can work together to progress. Finally, paradigm 5 sees science and theology through a lens of Concordism. This view sees theology and science as "describing the same kind of things about the same realm of reality."[13]

Tenneson, Bundrick, and Stanford administered the survey to several different populations including scientists at public and private institutions of higher education and students at Christian universities. However, a significant portion of the samples included individuals who did not match any of the science-theology paradigms. This was hypothesized by Tenneson, Bundrick, and Stanford as representing levels of religious commitment.[14] Perhaps those with less religious commitment had a less thought-out or consistent perspective on the relationship between science and theology. Also, many responses showed agreement with multiple paradigms. This indicates that the paradigms are not necessarily mutually exclusive. Perhaps this supports the conclusion that these views can be fluid or at least context specific.

For this study, the following research questions (RQ) were considered:

RQ1. What science-theology paradigms are present in this Christian college's student population?

RQ2. What are some factors that influence the science-theology paradigm choices?

Data

Data were collected through an online survey sent to residential and commuting undergraduate students at a midwestern Christian college during the fall semester of 2021. Although students are not required to endorse any statement of faith to attend, the statement signed by employees means most faculty are either young-earth or old-earth creationists. The survey did not ask denominational affiliation. But 34% of the student population that semester identified with a Protestant Christian denomination, 26% did not report a religious affiliation, 20% identified as "Christian," 18% as independent or nondenominational, and 3% as Roman Catholic. (The sum adds to more than 100% due to rounding.) Participation was incentivized by offering entry into a gift-card drawing. While 313 began the survey, only 221 provided usable data. 72 respondents failed to complete the survey (23%), and an additional 18 (6%) responses were lost due to technical error from the survey administration. Those who failed to finish stopped at various points in the survey, likely due to survey fatigue. The administration of the survey

was handled by a third party; thus, there is no way for the author to know why the 18 responses were lost. The rest of the study assumes that the lost data were random and therefore do not affect the results except through the loss of statistical power. Also, two respondents were removed from the analysis who did not mark that they believed in the existence of God. Removing these respondents focused the analysis on theists.

Of the 221 responses, 159 were from female students and 62 from male students. This means that the data are skewed toward females in comparison to the campus's gender ratio of 1.45/1 female to male. The sample is also skewed toward first-year students as the instructor of the first-year seminar took time in the class to encourage students to take the survey. In this dataset, 99 were first-year students, 49 were in their second year, 45 in their third, 25 in their fourth, and 3 were past the fourth year. Responses were divided by major into four groups. The groups were divided into science & math ($N=37$), engineering ($N=4$), Bible & ministry ($N=16$), and all others ($N=164$). Science & math was defined as having a major in the Department of Science & Mathematics. Therefore, students with majors in the social sciences and fields related to psychology were included in "other."

The survey asked a variety of questions focused on the students' beliefs about science and theology, science knowledge, and religious practices. Demographic and other information including gender, age, class year, race, and major were collected automatically through the campus database to avoid any priming of survey answers. Most survey items were statements, and students were asked to mark agreement on an anchored, Likert-style scale. The anchors were *strongly disagree* and *strongly agree*. The middle three choices were unlabeled so that data could be reasonably treated as a linear scale. All the questions were presented in the same order to all participants. However, that order was randomized. Therefore, questions that were grouped together in the analysis were not necessarily encountered together in the survey.

Science and Theology Paradigms

The primary focus of this study was the Science-Theology Paradigm framework used by Tenneson, Bundrick, and Stanford.[15] Five paradigms were measured by five questions each. The 25 questions and the corresponding paradigms are shown in table 1.

The Science-Theology Paradigm data were analyzed in two ways. Method 1 followed that of Tenneson, Bundrick, and Stanford. For each statement, responses of 4 or 5 (5 being strongly agree) were rated as "agreement" with the statement. If at least four out of five responses that matched a given paradigm were "agree," that student was marked as agreeing with the paradigm. Method 2 was a simple average of the responses to each of the paradigm's five statements. Therefore, a student was given a score on a scale of 1 to 5. A score of 1 corresponds to maximum disagreement with the paradigm and a score of 5 corresponds to maximum agreement.

Theological Beliefs and Religious Practices

Theology and religious questions asked about beliefs regarding miracles, the Bible, and religious practices. Religious practice questions were adapted from the Pew Religious Landscape Study.[16] These asked about regularity of prayer and worship service attendance. Another set of questions asked students which statement about the nature of God they agreed with the most. Options were, "God is a person," "God is an impersonal force," "I don't know," and "I don't believe in God." Three items about miracles were included which asked for students' agreement with the following statements: "Miraculous events described in the Old Testament actually happened just as described in the Bible," "Biblical accounts of Jesus's miracles in the New Testament happened just as described," and "The physical (bodily) resurrection of Jesus actually happened as described in the Bible." Additional questions about God's engagement with the world were taken from *Baylor Religion Survey, Wave II*.[17] Finally, students were asked which account of origins best matched their views. The choices are shown on table 2.

Science Knowledge

A measure of basic science knowledge included items from Dan Kahan (and references therein).[18] The questions are shown in table 3. If a student answered the question correctly, a score of 1 was recorded. An incorrect answer was awarded a score of 0. Scores were summed resulting in an overall score that could range from 0 to 8 with the maximum score denoting all correct answers.

Table 1: Science-Theology Paradigm Survey Items

Paradigm	Survey Question
Conflict: Science over Theology	Reliable information comes only as the result of investigation by the scientific method.
	All phenomena find their only true and complete description in the physical and chemical description of the behavior of matter.
	True knowledge about anything can come only from the scientific method, not from theology.
	A scientific description is the only meaningful description of reality that can be given.
	Science is the only valid source of insights into the nature of reality.
Conflict: Theology over Science	The Bible is literally and completely true even when it appears to contradict a scientific matter.
	Because the Genesis account of creation is true, evolution is necessarily false.
	Every part of biblical revelation that seems to present a scientific mechanism must surely do so with absolute authority and finality.
	We must reject any input from science that conflicts with a theological interpretation of the Bible.
	When theology and science conflict, theological conclusions must always take precedence over the claims of science.
Compartmentalism	Science and theology deal with entirely different realms of knowledge, and so they must be kept separate.
	Science can contribute nothing of significance to our understanding of theology, and theology can contribute nothing of significance to our understanding of science.
	Science has little or nothing to say about theology, and theology has little or nothing to say about science.
	Science and theology have little significance for each other.
	It is highly unlikely for science and theology to have any valid interaction.
Complementarism	Differing insights derived from both theology and science should be taken into account equally in the attempt to develop a more adequate and coherent view of the natural world.
	When using languages and methods appropriate to their own realms of discourse, both science and theology may provide different but meaningful descriptions of the same natural phenomena.
	Science and theology, when true to their respective principles and methodologies, provide differing, yet valid and relevant, insights that must be taken into account when describing the nature of reality.
	In order to obtain the fullest insight into the nature of reality, the different (but complementary) insights of science and theology should be integrated.
	Valid scientific descriptions and valid theological descriptions of the world will not contradict each other.
Concordism	Accurate scientific investigations of the natural world affirm the valid conclusions of theology.
	A scientifically constructed mathematical model for the existence of the universe would be logically consistent with a theologically derived explanation for why the universe exists.
	Descriptions of the natural world provided by science should be consistent with descriptions of the natural world provided by theology.
	Complete consistency between scripture and science regarding the ending of the universe should be attainable.
	Valid scientific descriptions and valid theological descriptions of the world will not contradict each other.

Table 2: Perspectives on Origins Included in the Survey

Answer Choice	Classification
"God created the Earth and all life on it within the last 10,000 years or so."	**Young-Earth Creation (YEC)**
"God created the universe almost 14 billion years ago, and at some point later created two humans who are the ancestors of all humans and who were not descended from any animal ancestors."	**Old-Earth Creation (OEC)**
"God created the universe almost 14 billion years ago and guided evolutionary processes in order to create all animals and humans from a single common ancestor."	**Evolutionary Creation (EC)**
"God created the universe almost 14 billion years ago and allowed natural evolutionary processes to run their courses without any guidance resulting in all animal and human life."	**Deistic Evolution (DE)**
"God had nothing to do with the origin of the universe or life on Earth."	**Atheism (omitted from analysis)**

Epistemological Views about Science

The survey included several questions to measure students' beliefs about science. These were measured using five possible student epistemological views (SEV) as reported by Chin-Chung Tsai and Shiang-Yao Liu.[19] The first view, Social Negotiation, views science in a constructivist way through negotiations between scientists. Second, the Invented and Created view sees science as "invented rather than discovered."[20] A third epistemological view is that of Theory-Laden Exploration. This view recognizes biases and presuppositions in the work of scientists. Fourth, the Cultural Impacts view sees science as culturally dependent. Finally, a fifth is the Changing and Tentative perspective that science is an evolving enterprise that makes tentative claims subject to further revision. The details of these survey items are shown in table 4.

After recoding for negatively coded items, each of the five views was averaged to obtain a score of 1 to 5. A lower score aligns with an empiricist or positivist epistemology of science, and a higher score aligns with a constructivist epistemology.

Table 3: Science Knowledge Battery Items

Question	Answer Choices
1. All radioactivity is manmade.	True/False
2. Lasers work by focusing sound waves.	True/False
3. Which gas makes up most of the Earth's atmosphere?	H_2, N_2, CO_2, O_2
4. Antibiotics kill viruses as well as bacteria.	True/False
5. The center of the Earth is much hotter than the surface of the Earth.	True/False
6. It is the father's genes that determine whether a baby is a boy or a girl.	True/False
7. Electrons are smaller than atoms.	True/False
8. The Earth goes around the sun.	True/False

Table 4: Survey Items Comprising the Students' Epistemological Views (SEV)

SEV Category	Survey Item
Social Negotiation	New scientific knowledge acquires its credibility through the recognition by many scientists in the field.
	Scientists share some agreed perspectives and ways of conducting research.
	The discussion, debates, and result sharing in the science community is one major factor facilitating the growth of scientific knowledge.
	Valid scientific knowledge requires the acknowledgement of scientists in relevant fields.
	Contemporary scientists have agreed upon an acceptable set of standards with which to evaluate scientific findings.
	Through the discussion and debates among scientists, the scientific theories become better.
Invented & Created	Scientists' intuition plays an important role in the development of science.
	Some accepted scientific knowledge comes from human's dreams and hunches.
	The development of scientific theories requires scientists' imagination and creativity.
	Creativity is important for the growth of scientific knowledge.
Theory-Laden Exploration	Scientists can make totally objective observations, which are not influenced by other factors.*
	Scientists' research activities will be affected by their existing theories.
	The theories scientists hold do not have effects on the process of their exploration in science.*
Cultural Impacts	People from different cultural groups have the same method of interpreting natural phenomena.*
	Scientific knowledge is the same in various cultures.*
	Different cultural groups have different ways of gaining knowledge about nature.
Changing & Tentative	The development of scientific knowledge often involves the change of concepts.
	Contemporary scientific knowledge provides tentative explanations for natural phenomena.
	Currently accepted science knowledge may be changed or totally discarded in the future.

* Items are reverse coded.

Analytic Plan

The data analysis can be grouped in two sections that roughly correspond to the two research questions, RQ1 and RQ2. First, the more general question, "What science-theology paradigms (found in table 1) are present in a Christian college's student population?" (RQ1) is answered through comparisons of paradigm results found in the current dataset. Along the way, I compare the results from this dataset to the previously published findings of Tenneson, Bundrick, and Stanford.[22] I also, like them, report on the relationship between paradigm choice and preferred account of origins. This also begins to answer RQ2.

The primary way in which I address RQ2, "What are some factors that influence the science-theology paradigm choices?" is by the construction of linear regression models. These models will be explained later with reference to tables 10 to 14.

Results

Science-Theology Paradigms

Table 5 presents the numbers and percentages for each paradigm, as chosen by students (using method 1) and, for comparison, includes data from Tenneson, Bundrick, and Stanford.[22] Complementarism was chosen by 43.4% ($N=96$) of the students followed by Conflict: Theology over Science (39.8%, $N=88$), and Concordism (27.6%, $N=61$). Only two students chose Conflict: Science over Theology (0.9%), and one chose Compartmentalism (0.4%). Because of respondents who matched multiple paradigms, the totals add to more than 100%.

Table 6 shows that a total of 59 (26.7%) of the sample matched no paradigm. In fact, only 42.1% of students matched only one science-theology paradigm. A breakdown of the number of paradigms matched is shown.

Of those who matched only one paradigm, the popularity order was the same. As shown on table 7, Complementarism was chosen by 46 students (49.5%), Conflict: Theology over Science by 34 (36.6%), and Concordism by 13 (14.0%). No student chose Conflict: Science over Theology or Compartmentalism.

Table 8 describes the combinations of multiple paradigms chosen by 69 students (31.2% of the 221 responses). Of the 88 who chose Conflict: Theology over Science (paradigm 2), 54 chose at least one other. Paradigm 2 was found in combination with Complementarism 20 times, with Concordism 17 times, and with both Complementarism and Concordism 15 times. One student chose the combination of Conflict: Theology over Science and Compartmentalism and one other student chose the combination of Theology over Science, Science

Table 5: Science-Theology Paradigms of Undergraduate Students at Christian College
Note: percentages add to more than 100% due to those who chose multiple paradigms.

Science-Theology Paradigm	This study % ($N=221$)	Tenneson, Bundrick, and Stanford % ($N=402$)
Complementarism	43.4% (96)	58.0% (223)
Conflict: Theology over Science	39.8% (88)	31.3% (126)
Concordism	27.6% (61)	33.1% (133)
None	26.7% (59)	19.9% (80)
Conflict: Science over Theology	0.9% (2)	1.0% (4)
Compartmentalism	0.4% (1)	1.2% (5)

Table 6: Responses That Used None, One, or Multiple Simultaneous Science-Theology Paradigms

Science-Theology Paradigm Used	This Study % ($N=221$)	Tenneson, Bundrick, and Stanford % ($N=402$)
None	26.7% (59)	19.9% (80)
One Only	42.1% (93)	42.5% (171)
Two Simultaneous	23.5% (52)	29.1% (117)
Three Simultaneous	7.7% (17)	8.0% (32)
Four Simultaneous	0.0% (0)	0.5% (2)
Total	100% (221)	100% (402)

Table 7: Science-Theology Paradigms of Students Who Chose Only One Paradigm ($N=93$)

Science-Theology Paradigm	% ($N=93$)
Complementarism	49.5% (46)
Conflict: Theology over Science	36.6% (34)
Concordism	14.0% (13)
Conflict: Science over Theology	0.0% (0)
Compartmentalism	0.0% (0)

over Theology, and Concordism. Concordism was chosen along with Complementarism by 14 students. Finally, one student chose a combination of Conflict: Science over Theology with Concordism and Complementarism.

One of the hypotheses put forward by Tenneson, Bundrick, and Stanford was that respondents who matched no science-theology paradigm were those with less religious commitment.[23] I compared the religiosity (using the definition of the Pew Religious Landscape Study[24]) of those who matched no science-theology paradigm with those who did. Religiosity was defined by a combination of church membership (Yes = 1, No = 0), a self-reported level of importance of religion (important or very important = 1, else = 0), regularity of service attendance (once or twice a month or more often = 1, else = 0), and regularity of prayer (a few times a week or more often = 1, else = 0). The sum of these four items resulted in a scale ranging from 0 to 4. The religiosity scores for both populations were nonparametric, skewing toward the maximum value of 4. Therefore, a Wilcoxon test was used to compare the religiosity of those without a paradigm match ($M = 2.97$, $Mdn = 3$, $N = 59$) to those with a paradigm match ($M = 3.44$, $Mdn = 3$, $N = 162$). The difference between the two populations was statistically significant ($w = 3833.5$, $p < 0.05$). This result suggests that Tenneson, Bundrick, and Stanford were correct in suggesting a relationship between a science-theology paradigm and religious commitment.

Table 8: Science-Theology Paradigms of Students Who Chose Multiple Paradigms (*N* = 69)

Science-Theology Paradigms	% (*N* = 69)
Conflict: Theology over Science with Complementarism	29.0% (20)
Conflict: Theology over Science with Concordism	24.6% (17)
Conflict: Theology over Science, Concordism, and Complementarism	21.7% (15)
Concordism with Complementarism	20.3% (14)
Conflict: Theology over Science with Compartmentalism	1.4% (1)
Conflict: Science over Theology, Concordism, and Complementarism	1.4% (1)
Conflict: Science over Theology, Conflict: Theology over Science, and Concordism	1.4% (1)

Paradigms Related to Origins Beliefs

Relationships between paradigm agreement and origins perspective are outlined on table 9. The left column shows the number and percentage of the population who chose each perspective on origins. The paradigms chosen by those claiming each origins perspective are shown in each row. While Tenneson, Bundrick, and Stanford ignored those with multiple paradigms, table 9 includes them. Therefore, the percentages across a row do not add to 100%. Young-earth creation was the preferred choice of 153 students (69.2%) followed by old-earth creation ($N = 45$, 20.3%), evolutionary creation ($N = 16$, 7.2%), and deistic evolution ($N = 7$, 3.2%). While those selecting young-earth creation were more likely to choose Conflict: Theology over Science, they were also less likely to select no science-theology paradigm and more likely to choose the Concordism paradigm compared to those who selected one of the other origins perspectives.

Linear Regression Models

Using the paradigm scores (the 1–5 scale of method 2 rather than the binary agree or disagree), five linear regression models were calculated. For each model, the dependent variable (outcome) was dependent on multiple independent variables (predictors). If the

Table 9: Science-Theology Paradigms by Origins Perspective (*N* = 221)

Origins Perspective (*N*, % of total)	None % (*N*)	Conflict: Science over Theology % (*N*)	Conflict: Theology over Science % (*N*)	Compartmentalism % (*N*)	Complementarism % (*N*)	Concordism % (*N*)
YEC (153, 69.2%)	20.3% (31)	0.6% (1)	49.7% (76)	0.0% (0)	42.5% (65)	34.6% (53)
OEC (45, 20.3%)	37.8% (17)	0.0% (0)	22.2% (10)	2.2% (1)	44.4% (20)	6.7% (3)
EC (16, 7.2%)	43.8% (7)	0.0% (0)	12.5% (2)	0.0% (0)	50.0% (8)	18.8% (3)
DE (7, 3.2%)	57.1% (4)	14.3% (1)	0.0% (0)	0.0% (0)	42.8% (3)	28.6% (2)

YEC = young-earth creation; OEC = old-earth creation; EC = evolutionary creation; DE = deistic evolution

model found that a predictor was statistically significant at the $p \leq 0.05$ level or better, it was included in the final model. (Control variables are included no matter the significance level.) The effect of each predictor on the outcome is described by the "estimate." Tables 10–14 show each predictor's estimate (the slope of the linear relationship), estimate error, and statistical significance level.

The five linear regression models were calculated using demographic controls, plus other predictors were hypothesized to affect views on science and theology. Demographic controls were gender, academic area, and year in school. Academic area was categorized by majors. Majors were divided into four areas: science and math, engineering, Bible/ministry, and all others. All three controls were analyzed as categorical rather than linear variables. Academic area was analyzed with the reference level as "other," and the year in college with reference level of year 1.

All models began with a number of hypothesized predictors which were removed using backward elimination to produce a model that included only the controls and those predictors that were significant at the $p < 0.05$ level. The predictors that were included from the beginning were those asking about religious practices (prayer and church attendance), theological beliefs, science knowledge, student's epistemological view, and the other paradigm scales.

Of these predictors, beliefs about origins and the question about God's nature as a person were treated categorically. Because young-earth creation was the most common response, it was the reference level for the belief about origins variable. The other categorical variable asked, "Which comes closest to your view of God?" Here the most common response, "God is a person," was used as the reference level.

Paradigm 1 – Conflict: Science over Theology

Table 10 shows the result for the paradigm 1 model. The control of year in school shows only year 3 with a statistically significant effect. Because of the categorical nature of the variable, a significant result means that the predictor (year 3 in this case) is statistically significant in comparison to the baseline of year 1. The control variable of major showed a statistically significant relationship between being a science or math major and higher score on paradigm 1.

Belief in biblical accounts of miracles is significantly and negatively related to score on paradigm 1. There is a significant and positive relation between believing that God is "an impersonal force" and score on paradigm 1.

Among the other paradigms, paradigm 2 (Conflict: Theology over Science) is negatively related to score on paradigm 1. On the other hand, higher scores on paradigm 3 (Compartmentalism) are very significantly and strongly predictive of higher scores on paradigm 1. Higher paradigm 5 (Concordism) scores are also related to higher paradigm 1 scores.

Table 10: Linear Regression Model with Outcome of Conflict: Science over Theology Score
($df = 196$); ns: not significant; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$

Parameter	Estimate	Standard Error	Significance
Intercept	1.97	0.46	***
Controls			
Gender (Male)	0.02	0.08	ns
Year at College			
Year 2†	0.07	0.09	ns
Year 3†	0.20	0.09	*
Year 4†	-0.02	0.12	ns
Year 5†	0.41	0.31	ns
Academic Area			
Science & Math	0.23	0.10	*
Engineering	0.04	0.27	ns
Bible/Ministry	-0.09	0.14	ns
Other Predictors			
Belief in Biblical Miracles	-0.17	0.06	**
Nature of God: "God is an impersonal force."‡	0.19	0.08	*
"I don't know." ‡	0.01	0.13	ns
SEV – Social Negotiation	0.22	0.06	***
SEV – Theory-Laden Exploration	-0.23	0.06	***
Paradigm 2 Scale (Conflict: Theology over Science)	-0.16	0.05	**
Paradigm 3 Scale (Compartmentalism)	0.39	0.06	***
Paradigm 5 Scale (Concordism)	0.20	0.06	***
Adjusted $R^2 = 0.45$			

† Reference Level is Year 1
‡ Reference level is "God is a person."
SEV = student's epistemological view

Some of the students' epistemological views (SEV) also are significantly related to paradigm 1 scores. While Social Negotiation is positively related to scores on paradigm 1, Theory-Laden Exploration views are negatively related. So, while students who see science as the result of discussion and negotiation between scientists score higher on paradigm 1, those who think that biases and existing theories can influence scientific pursuits score lower.

Paradigm 2 – Conflict: Theology over Science

A linear regression model with paradigm 2 as an outcome is shown in table 11. Here also the year in college is significant as year three and year four are both negatively related to score on paradigm 2 (again with respect to year 1). All other control variables were statistically insignificant.

Old-earth creation, evolutionary creation, and deistic evolution are all negatively related to paradigm 2 with respect to young-earth creation. Belief in biblical miracles is also a significant positive predictor.

Table 11: Linear Regression Model with Outcome of Conflict: Theology over Science Score
($df = 202$); ns: not significant; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$

Parameter	Estimate	Standard Error	Significance
Intercept	2.50	0.36	***
Controls			
Gender (Male)	-0.03	0.10	ns
Year at College			
Year 2†	-0.17	0.11	ns
Year 3†	-0.24	0.11	*
Year 4†	-0.39	0.14	**
Year 5†	-0.37	0.38	ns
Academic Area			ns
Other Predictors			
Belief in Biblical Miracles	0.43	0.07	***
Origins Perspective:			
Old-Earth Creation‡	-0.44	0.12	***
Evolutionary Creation‡	-0.66	0.18	***
Deistic Evolution‡	-0.83	0.25	**
Paradigm 4 Scale (Complementarism)	-0.28	0.07	***
Paradigm 5 Scale (Concordism)	0.16	0.06	*
Adjusted $R^2 = 0.42$			

† Reference Level is Year 1
‡ Reference is Young-Earth Creation Perspective

Scores on paradigm 4 were negatively related to paradigm 2 while scores on paradigm 5 were positively related to paradigm 2. None of the students' epistemological views was related to paradigm 2 at a statistically significant level.

Paradigm 3 – Compartmentalism

Table 12 shows the paradigm 3 model. Having a science or math major was negatively related to Compartmentalism score. All other control variables were insignificant.

The Social Negotiation SEV was negatively related to scores on paradigm 3. Finally, as we have seen before, there is a positive relationship between paradigm 1 and paradigm 3 scores. But both paradigms 4 and 5 are negatively related to paradigm 3.

Table 12. Linear Regression Model with Outcome of Compartmentalism
($df = 202$); ns: not significant; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$

Parameter	Estimate	Standard Error	Significance
Intercept	3.29	0.30	***
Controls			
Gender (Male)	0.09	0.08	ns
Year at College			ns
Academic Area			
Science & Math	-0.21	0.10	*
Engineering	0.26	0.32	ns
Bible/Ministry	0.09	0.14	ns
Other Predictors			
SEV – Social Negotiation	-0.23	0.07	**
Paradigm 1 Scale (Conflict: Science over Theology)	0.48	0.06	***
Paradigm 4 Scale (Complementarism)	-0.20	0.07	**
Paradigm 5 Scale (Concordism)	-0.28	0.05	***
Adjusted $R^2 = 0.48$			

SEV = student's epistemological view

Paradigm 4 – Complementarism

No control variable was statistically significant in the paradigm 4 model, shown in table 13. Belief in biblical miracles was positively related to paradigm 4. Among the SEV, both Social Negotiation and Changing and Tentative were significantly and positively related to paradigm 4. This was the only model for which the Changing and Tentative dimension

Table 13: Linear Regression Model with Outcome of Complementarism
(*df* = 203); ns: not significant; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$

Parameter	Estimate	Standard Error	Significance
Intercept	1.08	0.32	***
Controls			
Gender (Male)	-0.04	0.08	ns
Year at College			ns
Academic Area			ns
Other Predictors			
Belief in Biblical Miracles	0.23	0.06	***
SEV – Changing and Tentative	0.24	0.07	***
SEV – Social Negotiation	0.36	0.07	***
Paradigm 2 Scale (Conflict: Theology over Science)	-0.17	0.05	**
Adjusted $R^2 = 0.35$			

SEV = student's epistemological view

Table 14: Linear Regression Model with Outcome of Concordism
(*df* = 197); ns: not significant; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$

Parameter	Estimate	Standard Error	Significance
Intercept	1.95	0.58	***
Controls			
Gender (Male)	0.19	0.09	*
Year at College			ns
Academic Area			ns
Other Predictors			
Nature of God: "God is an impersonal force."†	-0.37	0.10	***
"I don't know."†	-0.07	0.16	ns
SEV – Cultural Impacts	0.14	0.06	*
SEV – Theory-Laden Exploration	0.20	0.08	**
Paradigm 1 Scale (Conflict: Science over Theology)	0.27	0.08	***
Paradigm 2 Scale (Conflict: Theology over Science)	0.27	0.06	***
Paradigm 3 Scale (Compartmentalism)	-0.41	0.08	***
Paradigm 4 Scale (Complementarism)	0.16	0.07	*
Adjusted $R^2 = 0.34$			

† Reference level is "God is a person."
SEV = student's epistemological view

of SEV was a significant predictor. Finally, the paradigm 2 score had a negative relationship with paradigm 4.

Paradigm 5 – Concordism

Table 14 shows the model for paradigm 5. None of the controls was statistically significant. The predictor of belief in "God is an impersonal force" had a negative relationship to paradigm 5. Both the Theory-Laden Exploration SEV and Cultural Impacts SEV had statistically significant positive relationships to paradigm 5.

All other paradigm scores had a statistically significant relationship to Concordism. Paradigms 1, 2, and 4 had positive relationships while paradigm 3 was negative.

Discussion

Comparing the science-theology paradigms between this study and the prior work, we see several similarities. Table 5 and table 6 compare results from this study directly with those of Tenneson, Bundrick, and Stanford. A higher percentage of respondents in this study chose no paradigm. Also, slightly higher numbers chose paradigm 2 and fewer chose paradigms 4 and 5. Both studies showed low percentages of paradigms 1 and 3. While the populations are different—the current study did not include faculty—the results are qualitatively similar. The especially low percentages of paradigms 1 and 3 responses in comparison to the others lend credence to the reliability of the survey instrument.

But what are we to make of the significant number of responses which matched no science-theology paradigm or those that matched multiple paradigms? The finding that students who matched at least one science-theology paradigm had higher religiosity scores suggests that Tenneson, Bundrick, and Stanford were correct, that there may be a relationship between greater religious commitment and matching at least one science-theology paradigm. Kyle Longest and Christian Smith found that religiousness (defined by importance of faith, reading scriptures, and committing to live for God) among young adults was positively related to viewing science and faith as compatible and rejecting a conflict view.[25] A similar finding was that young adults who attended Protestant high schools viewed science and faith

as compatible, agreed that their faith was strengthened by science, and rejected conflict between faith and science. Perhaps the process of thinking deeply about and knowing one's faith causes better integration with other aspects of life. Further research should investigate this relationship.

This result raised the question of whether the relationship also worked in the other direction. Does increased science expertise relate to science-theology paradigms? Elaine Ecklund and Jerry Park found that elite scientists were less likely to endorse conflict between science and faith than the general population and even the well-educated population.[26] Is there a difference in science fluency between those who did not match a science-theology paradigm and those who did? A comparison by means of a t-test showed that the science knowledge (see table 3) of those who did not match a paradigm ($M = 5.0$, $SD = 1.6$) was significantly ($t(90.8) = -4.8$, $p < 0.001$) lower than those who did match a paradigm ($M = 6.1$, $SD = 1.4$). Perhaps the process of knowing science better also causes better integration with faith.

A few things should be mentioned here. First, this work did not find religiosity nor science knowledge to be significantly correlated to any one paradigm (see tables 10–14). This is only a connection between religiosity or science knowledge and matching a paradigm. Also, the results of Longest and Smith and Ecklund and Park mentioned above were specifically those of people embracing a compatible view of faith and science and rejecting a conflict view.[27] In the current dataset and that of Tenneson, Bundrick, and Stanford, matching a paradigm also includes the possibility of embracing a conflict view.[28]

Unfortunately, it is not as simple as dividing those in the dataset who chose Conflict or Compartmentalism paradigms from those with Complementarism or Concordism paradigms. As we have seen (table 8), many students match multiple paradigms, including 52 students (24% of all responses) who chose paradigm 2, Conflict: Theology over Science *and* one or both of Complementarism and Concordism. This is more than the number of students (table 7, $N = 34$) who chose paradigm 2 alone. This raises an important question of whether the questions identifying paradigm 2 are valid. That is, are those items accurately identifying those who genuinely view science and theology in conflict?

As noted earlier, one's perspective on the relationship between faith and science is context dependent.[29] If researchers are interested in a broad perspective on this relationship, it is probably best to not use questions that are context specific such as those asking about acceptance of evolution.[30] Pratchayapong Yasri et al. also point out that many of the taxonomies focus on different aspects of the faith-science relationship. Some emphasize the explanations while others focus on epistemology. Still others focus on metaphysics. In the current survey instrument, we see a mixture of these, especially in the questions for paradigm 2. One statement explicitly addresses the evolution question: "Because the Genesis account of creation is true, evolution is necessarily false." But the more general questions for paradigm 2 can be seen to be compatible with the paradigms of Complementarism and Concordism. One says, "The Bible is literally and completely true even when it appears to contradict a scientific matter." One can easily view science and Christian faith in harmony (thinking metaphysically) while acknowledging that epistemologically there might be an *appearance* of conflict. In addition, the statement, "When theology and science conflict, theological conclusions must always take precedence over the claims of science," can be agreed to by someone who denies that there are any real conflicts, but believes that there is only the *appearance* of conflicts. Or one could reject a conflict view of science and faith while still agreeing with these statements if one were employing the theological conservatism principle that Theodore Cabal and Peter Rasor argue is the typical response of Christians to perceived conflict between their faith and science.[31]

According to Margaret Evans et al., such a person would likely be employing a coexistence model of cultural beliefs.[32] This student is accepting both scientific and supernatural epistemologies simultaneously. When explicitly asked about the priority of biblical or theological epistemic claims, the student may agree. However, on the whole, this student harmonizes both epistemologies to assemble a metaphysical or explanatory model.

While the large number of overlapping paradigms raises questions about the interpretation of the paradigms, there are still reasons to think that they identify important characteristics of the students' beliefs. These are seen in the linear models in tables 10–14. These are described below by looking at

the various predictors that were statistically significant in the linear models.

Origins Perspective

Origins perspectives were significant for only the Conflict: Theology over Science paradigm. Since young-earth creationism (YEC) was the reference level of the variable (table 11), every other perspective scores significantly lower on the paradigm 2 score. So, even if using method 1 (identifying binary agreement) to analyze paradigm 2 might not adequately capture a conflict viewpoint, method 2 (calculating a score of agreement) does show what we expect. In fact, the estimate for each origins perspective increases as we approach deistic evolution. That is, deistic evolution beliefs predict a score of 0.83 less on the paradigm 2 score than young-earth creation, evolutionary creation predicts 0.66 less on the paradigm 2 score, and old-earth creation only 0.44 less. The relationships show that the more evolutionary and cosmological theory the students accept, the lower their agreement with paradigm 2 will be. This result matches what would be expected if the paradigm 2 score does measure the amount of agreement with a Conflict: Theology over Science viewpoint.

The Nature of God

In the models for paradigms 1 and 5, the question about the nature of God was significant. Here a positive relationship with paradigm 1 (table 10) and a negative relationship with paradigm 5 (table 14) was found with the response that "God is an impersonal force." The comparison level is to those who responded that "God is a person." It appears that those who do not have an orthodox view of the nature of God are less likely to see science and Christian faith in harmony through the Concordism paradigm and more likely to see science as superior to theology. This supports the view stated earlier that those who have thought through and know their faith are more likely to see harmony between their faith and science.

Miracles

Not surprisingly, a belief that the biblical descriptions of miracles (both Old and New Testament) literally happened was negatively correlated to paradigm 1 and positively to paradigm 2 (tables 10 and 11). But it is interesting to note that it was also a statistically significant positive predictor of paradigm 4 (table 13), but not of paradigm 5 (table 14). Perhaps, like religiosity, believing in the accounts of miracles represents a well-developed faith leading to a harmonious viewpoint like that of Completmentarism. But, in the minds of some students, miracles may be the ultimate example of an irreconcilable difference between the natures of faith and science that prevent full endorsement of a Concordism paradigm. This would be an interesting area for further study.

Students' Epistemological Views (SEV) of Science

What might be the most intriguing results from these models are those relating to the SEV measurements. Of the five SEV dimensions used, only one, created and invented, did not appear as a significant predictor in any model.

The Social Negotiation dimension was significant for three models. It was a positive relationship to paradigms 1 and 4 and negative with paradigm 3. Since the Social Negotiation dimension emphasized the collaborative nature of science, I hypothesize that the positive relationship to paradigm 1 could arise from those students' faith in peer review and scientific consensus, leading to their placing extra credibility to science over theology. However, direct causal links to paradigms 3 and 4 are less clear.

it is interesting to note that the integration leaning paradigms (Complementarism and Concordism) both had positive relationships with two SEV each. Since a positive score on an SEV represents a "sophisticated" view of the nature of science, we again see a possible link between a knowledgeable and developed view of science and a positive view of the faith-science relationship. On the other hand, the only two negative SEV relationships were to Conflict: Science over Theology and Compartmentalism.

The Theory-Laden Exploration of science appeared in two models. It was a positive predictor for Concordism and a negative predictor for Conflict: Science over Theology. Since Theory-Laden Exploration recognizes biases and presuppositional influences on the work of scientists, perhaps those who recognize it are therefore less likely to place extra credibility on science over theology (paradigm 1).

Perhaps an acknowledgment of biases, prejudices, and presuppositions in science is required to see science and theology in unified harmony (paradigm 5).

Two SEV dimensions, Changing and Tentative along with Cultural Impacts, were found in one model each. The relationship between Changing and Tentative and Complementarism was significant and positive along with Cultural Impacts with Concordism.

Specific causal links between these SEV dimensions and the paradigms could be a fruitful area for future research. Such work could also further test the hypothesis that a sophisticated view of science lends itself to choosing harmonious perspectives on faith and science.

Other Paradigms

Each model also included the other paradigm scores. The negative or positive effect varied across the models. See tables 10–14 for the details. Some of the connections seem obvious. Paradigm 2 was negatively predictive of paradigm 1. Paradigms 1 and 3 had significant, positive relationships with each other. Conflict and separation might go hand-in-hand. However, the story cannot be that simple since the Conflict: Theology over Science paradigm does not see a similar positive relationship to Compartmentalism. Perhaps issues with respect to the validity of paradigm 2 discussed above are at play here.

A positive relationship of paradigm 4 to paradigm 5 is also expected given the prior work.[33] But it is interesting to note that the effect size from paradigm 4 to 5 is smaller than some of the other relationships such as 1 to 3, 2 to 5, and even 1 to 5! Another strange result is that paradigm 4 is negatively related to paradigm 2 while paradigm 5 is positively related to paradigm 2. While some of these relationships seem straightforward, others are not.

In addition, while some paradigms appear to be opposed, most are not mutually exclusive. This is even apparent from the wording of the questions. As argued before, beliefs about the relationship between science and theology are likely very context specific. Results such as these show that the students cannot always be pigeonholed into neat, separate paradigms by this survey.

Future research here should focus on several predictors. First, can the survey instrument be improved to better identify science-theology paradigms? Work in this area should focus on making the items less context specific. Perhaps also, insight from Yasri et al. and Evans et al. could help in identifying epistemological paradigms separately from explanatory or metaphysical paradigms.[34] These may operate in different combinations. For example, a young-earth or old-earth creationist might have a metaphysical worldview that sees no conflict between scientific pursuit and Christian faith while at the same time being skeptical of specific epistemological claims made by scientists and elevating the epistemological claims of the Bible. Such an individual would likely score high on both the Concordism and Conflict: Theology over Science paradigms in the survey's current format.

Conclusions

The survey instrument for science-theology paradigms was employed to identify the paradigms used by Christian college students at this institution. Results showed that there are often complex relationships between the various science-theology paradigms. Many students used multiple paradigms, often including a conflict paradigm. The results suggest the context-dependent nature of these paradigms.

The specific breakdown of origins beliefs and science-theology paradigms varies slightly from the previous work,[35] although it shows some similar patterns. However, they represent the beliefs of only a small sample at one institution. The results are likely to change from one institution to another based on student background and theological commitments of the school. Future work could expand to include multiple institutions of varying denominations or theological perspectives in order to identify variations in paradigm choice that might arise from such differences.

When connected with religious practices, beliefs, science knowledge, and beliefs about the nature of science, an interesting story emerges. Students who are more engaged with their faith and more knowledgeable about basic science are more likely to be identified with one of the science-theology paradigms. Even more specifically, those who have

an orthodox view of God (a person rather than a force), those who believe the biblical accounts of miracles, and those with sophisticated views on the nature of science are more likely to score higher on Complementarism or Concordism paradigms. Future work should investigate these relationships using qualitative or mixed-methods research. For example, interviews with students who display intriguing combinations of science-theology paradigms and epistemological beliefs could reveal relationships undetected by the quantitative data.

The current study did not include enough responses to probe how these beliefs might change over a college career. Further work that increases sample size and/or collects longitudinal data might shed light on this interesting question. In this data, there was a statistically significant difference between freshmen and upperclassmen on the question about the nature of God. Increasing the statistical power of the data with a larger sample size might reveal more differences as a result of the college experience. The best way to answer that question would be to administer the survey on a regular basis to the same population of students in order to track changes among matched responses. ☼

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Notes

[1]John H. Evans and Michael S. Evans, "Religion and Science: Beyond the Epistemological Conflict Narrative," *Annual Review of Sociology* 34 (2008): 87–105, https://doi.org/10.1146/annurev.soc.34.040507.134702; Elaine Howard Ecklund and Jerry Z. Park, "Conflict between Religion and Science among Academic Scientists," *Journal for the Scientific Study of Religion* 48, no. 2 (2009): 276–92, https://www.jstor.org/stable/40405617; Christopher P. Scheitle, "U.S. College Students' Perception of Religion and Science: Conflict, Collaboration, or Independence? A Research Note," *Journal for the Scientific Study of Religion* 50, no. 1 (2011): 175–86, https://doi.org/10.1111/j.1468-5906.2010.01558.x; John H. Evans, "Epistemological and Moral Conflict between Religion and Science," *Journal for the Scientific Study of Religion* 50, no. 4 (2011): 707–27, https://doi.org/10.1111/j.1468-5906.2011.01603.x; Kyle C. Longest and Jeremy E. Uecker, "It All Depends on What You Want to Believe: How Young Adults Navigate Religion and Science," *Review of Religious Research* 63, no. 1 (2021): 1–21, https://doi.org/10.1007/s13644-020-00436-9; and Elaine Howard Ecklund, Jerry Z. Park, and Katherine L. Sorrell, "Scientists Negotiate Boundaries between Religion and Science," *Journal for the Scientific Study of Religion* 50, no. 3 (2011): 552–69, https://doi.org/10.1111/j.1468-5906.2011.01586.x.

[2]Timothy L. O'Brien and Shiri Noy, "Traditional, Modern, and Post-Secular Perspectives on Science and Religion in the United States," *American Sociological Review* 80, no. 1 (2015): 92–115, https://www.jstor.org/stable/24756701.

[3]Pablo de Felipe and Malcolm A. Jeeves, "Science and Christianity Conflicts: Real and Contrived," *Perspectives on Science and Christian Faith* 69, no. 3 (2017): 131–47, https://www.asa3.org/ASA/PSCF/2017/PSCF9-17deFelipe.pdf.

[4]Deena Skolnick Weisberg et al., "No Missing Link: Knowledge Predicts Acceptance of Evolution in the United States," *BioScience* 68, no. 3 (2018): 212–22, https://doi.org/10.1093/biosci/bix161.

[5]Leslie J. Rissler, Sarah I. Duncan, and Nicholas M. Caruso, "The Relative Importance of Religion and Education on University Students' Views of Evolution in the Deep South and State Science Standards across the United States," *Evolution: Education and Outreach* 7, no. 24 (2014), https://doi.org/10.1186/s12052-014-0024-1.

[6]Pew Research Center, "Religious Landscape Study," n.d., https://www.pewforum.org/religious-landscape-study/.

[7]Ian G. Barbour, *When Science Meets Religion: Enemies, Strangers, or Partners* (New York: HarperSanFrancisco, 2000).

[8]John Hedley Brooke, *Science and Religion: Some Historical Perspectives* (Cambridge, UK: Cambridge University Press, 1991).

[9]Michael Tenneson, David Bundrick, and Matthew Stanford, "A New Survey Instrument and Its Findings for Relating Science and Theology," *Perspectives on Science and Christian Faith* 67, no. 3 (2015): 200–222, https://www.asa3.org/ASA/PSCF/2015/PSCF9-15Tenneson.pdf.

[10]David R. Bundrick, "The Development of a Scale to Identify College and University Science Professors' Science-Faith Paradigms" (PhD diss., University of Missouri-Columbia, 2003), ProQuest (AAI3091906).

[11]Tenneson, Bundrick, and Stanford, "A New Survey Instrument."

[12]Barbour, *When Science Meets Religion.*

[13]Tenneson, Bundrick, and Stanford, "A New Survey Instrument."

[14]Ibid.

[15]Ibid.

[16]Pew Research Center, "Religious Landscape Study."

[17]Baylor University, *Baylor Religion Survey, Wave II* (Waco, TX: Baylor Institute for Studies of Religion, 2007).

[18]Dan M. Kahan, "'Ordinary Science Intelligence': A Science-Comprehension Measure for Study of Risk and Science Communication, with Notes on Evolution and Climate Change," *Journal of Risk Research* 20, no. 8 (2017): 995–1016, https://doi.org/10.1080/13669877.2016.1148067.

[19]Chin-Chung Tsai and Shiang-Yao Liu, "Developing a Multi-Dimensional Instrument for Assessing Students' Epistemological Views toward Science," *International Journal of Science Education* 27, no. 13 (2005): 1621–38, https://doi.org/10.1080/09500690500206432.

[20]Ibid.

[21]Tenneson, Bundrick, and Stanford, "A New Survey Instrument."

[22]Ibid.
[23]Ibid.
[24]Pew Research Center, "Religious Landscape Study."
[25]Kyle C. Longest and Christian Smith, "Conflicting or Compatible: Beliefs about Religion and Science among Emerging Adults in the United States," *Sociological Forum* 26, no. 4 (2011): 846–69, https://doi.org/10.1111/j.1573-7861.2011.01287.x.
[26]Ecklund and Park, "Conflict between Religion and Science."
[27]Longest and Smith, "Conflicting or Compatible"; Ecklund and Park, "Conflict between Religion and Science."
[28]Tenneson, Bundrick, and Stanford, "A New Survey Instrument."
[29]Brooke, *Science and Religion*.
[30]Pratchayapong Yasri et al., "Relating Science and Religion: An Ontology of Taxonomies and Development of a Research Tool for Identifying Individual Views," *Science & Education* 22, no. 10 (2013): 2679–707, https://doi.org/10.1007/s11191-013-9623-4.
[31]Theodore J. Cabal and Peter J. Rasor II, *Controversy of the Ages: Why Christians Should Not Divide over the Age of the Earth* (Wooster, OH: Weaver Book Company, 2017), 40–46.
[32]E. Margaret Evans, Cristine H. Legare, and Karl S. Rosengren, "Engaging Multiple Epistemologies: Implications for Science Education," in *Epistemology and Science Education: Understanding the Evolution vs. Intelligent Design Controversy*, ed. Roger S. Taylor and Michel Ferrari (New York: Routledge, 2010), 111–39.
[33]Tenneson, Bundrick, and Stanford, "A New Survey Instrument."
[34]Yasri et al., "Relating Science and Religion"; Evans, Legare, and Rosengren, "Engaging Multiple Epistemologies."
[35]Tenneson, Bundrick, and Stanford, "A New Survey Instrument."

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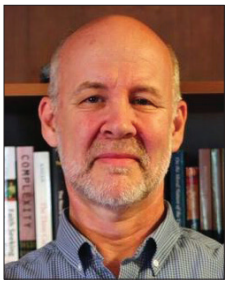

Chris Barrigar

Essay Book Review

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Re-ordering Faith and Science: Tyson's Project to Reverse the Great Reversal

Chris Barrigar

A CHRISTIAN THEOLOGY OF SCIENCE: Reimagining a Theological Vision of Natural Theology by Paul Tyson. Grand Rapids, MI: Baker Academic, 2022. 224 pages. Paperback; $24.99. ISBN: 9781540965516.

Theologian Paul Tyson has published a new theology of science. His concern is to address "the great reversal," whereby the early figures in natural philosophy held Christian faith as "first truth" and their scientific findings as "second truth," but over the course of two-and-a-half centuries these became reversed—the findings of science became society's "first truth" and Christian faith became privatized "second truth." Some Christians, particularly those in science-and-religion discussions today, have succumbed to this reversal, making reductionist-materialist science their operational first truth. Tyson critiques the latter, keying on proposals to reinterpret the Fall as non-historical. This review summarizes Tyson's argument, identifies valuable aspects to his proposal, and then offers a number of constructive critiques.

Keywords: theology of science, the Fall, methodological naturalism, reductionism, reductionist-materialism, mythos, Christian epistemology

Paul Tyson's project is motivated by a particular concern—that some Christians ("religion-and-science" theologians in particular) are sacrificing core Christian belief to the reductionist-materialist epistemology of contemporary science. On Tyson's view, redressing this problem requires a proper theology of science, undergirded by a Christian epistemology, which is the task he sets himself here. His chosen task is a theology of the knowledge of creation, not a theology of creation itself.

My lens in reviewing this book is as a philosophical theologian serving in the community of practicing scientists, in a sense, as a translator between the worlds of academic science and academic theology. From this view, I find Tyson's proposal incisive, stimulating, and important, and so I recommend it to readers of this journal. At the same time, though, many nontheologically trained readers will find the book a challenge to get through. Indeed, Tyson's conceptual richness is precisely why his argument is challenging to follow. While the book is aimed at theologians, Tyson does try to make the book accessible to nontheologians, particularly by providing a helpful glossary of technical philosophical and theological terms at the end for nonspecialist readers. Nonetheless, as the book progresses, each chapter gets conceptually denser, which by the later chapters (especially chap. 7 onward) can make the discussion particularly challenging to follow. So, I begin by providing a summary of his argument before moving to assess his proposal.

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Summary

Tyson enters into the subject by making a distinction between "first truth" and "second truth." On Tyson's account, the early modern natural philosophers (early figures of the Scientific Revolution) held to Christian doctrine as "first truth," and then interpreted their scientific findings as "second truth" within, or through the lens of, Christian faith. Nonetheless, through the seventeenth to nineteenth centuries, a number of epistemological moves took place (Tyson helpfully describes this history) so that, by the late 1800s, empiricist and rationalist accounts of the knowledge of nature combined to produce "reductionist materialism" as the dominant interpretation of the natural order within Western intellectual culture.

Here, though, we should define our terms. "Reductionism," as defined by Tyson, is "a metaphysical outlook … the 'pure matter' perspective that takes physical reality to be the only reality that defines nature" (p. 189). Christian theology is "incompatible … with post-nineteenth century empiricist and rationalist accounts of the knowledge of nature" (p. 54). Tyson is not saying that Christian theology is incompatible with the findings of modern scientific method; he is saying that Christian theology is incompatible with reductionist-materialist interpretations of the findings of modern science.

Tyson calls the historical move of reductionist materialism supplanting Christian theology "the great reversal." That is, Christian theology, which for centuries had been society's public "first truth," came to be displaced by reductionist materialism as society's new "first truth," rendering Christian theology private "second truth." Which brings us to the issue that provides Tyson's central concern: Christians in the field of "religion-and-science" today often succumb to this nineteenth-century reversal by "overlapping" the reductionist-materialist interpretations of modern science with doctrinal categories of Christian faith—but they do so in a way that concedes first truth to reductionist materialism, thereby compromising creedal Christian faith. In effect, Tyson's objective is to reverse this reversal in theology today.

The central (indeed only) exhibit in Tyson's account of how the great reversal has infiltrated Christian theology is the doctrine of the historical Fall of humanity and creation, for there are Christian theologians and scientists who, acceding to this reversal, deny a historical Fall. Let us call such persons "overlappers."[1] Their rationale arises from the findings of science—that the universe, including its biological processes and hominid history, has always been a place of violence, destruction, and death. Consequently, there has never been an Edenic or nonviolent state, whether for humanity or for the universe as a whole, and thus no historical Adamic or cosmic Fall from an Edenic state. It should be noted that this does not predetermine the historicity of Adam and Eve: as seen in the pages of this journal, some overlappers argue for some form of historic Adam and Eve in the history of humanity, while others argue against their historicity.

This is a topic of considerable interest to many ASA members, whether in the pages of *PSCF* or in conference conversations. Within the ASA are those who, such as Joshua Swamidass, want to retain a historical Adam and Eve, and thus a historical Fall,[2] while there are others, such as George Murphy, who hold that "there is little to be gained by continuing to insist on a 'historical Adam'"[3] (or a historical Fall of Adam). Tyson believes, though, that there is much of critical importance to Christian faith that is sacrificed in denying a historical Fall (the specifics of which we will see further below).

Nonetheless, Tyson believes that truth is a unity; thus, science should indeed be integrated with faith, but the direction of integration is critical. The denial of a historical Fall amounts to doing theology as "religion-within-science," which is the method of the overlappers but which compromises creedal Christian Faith. Tyson rejects this in favor of integration through "science-within-religion," for this retains Christian faith as first truth. But then, *how* should we apply science-within-religion (or, more precisely, science-within-faith), according to Tyson?

His first step is to critique reductionist materialism. He argues that natural things (the universe, rocks, puppies) possess both physical and metaphysical properties, but reductionism fallaciously removes, indeed denies, nature's metaphysical properties (particularly, essence, meaning, purpose, aesthetics, value, and wisdom). So, we need a Christian framework by which to reattach metaphysics to nature as understood by the investigative methods of modern science.

To this end, Tyson proposes using Plato's notion of "Awareness" as our fundamental epistemological

category; then, within awareness, he proposes separate subcategories of *knowledge* and *understanding*. He further subdivides these, to produce the following four-tier framework by which to reintegrate the metaphysical with the physical:

> High Understanding—Essential illumination
> (wisdom and true/ultimate meaning)
>
> High Knowledge—Rational illumination
> (mathematics, quantification, logic)
>
> Low Understanding—Existential illumination
> (belief, theory [including scientific theory], myth)
>
> Low Knowledge—Empirical illumination
> (the functional reductionist findings of science)[4]

This four-part hierarchy, or "integrative zone," provides Tyson's central proposal for how to integrate Christian belief with the findings and theories of science. Within this hierarchy, reductionist science, "as practiced by modern scientists, will yield genuine epistemic light at the level of perception-dependent and mathematically reasoned truth" (p. 159). That is, reductionism can indeed yield genuine low and high knowledge; however, reductionism produces emaciated accounts of high and low understanding, leaving humanity greatly impoverished. For instance, low and high understandings get relegated to the private sphere, describing religious belief as "an infantile psychological need to believe such things" (p. 129), and rendering myth equivalent to fiction.

The mention of myth brings us to the central concept by which Tyson critiques the overlappers—namely, *mythos*—for "any unified lifeworld must have its guiding mythos" (p. 132). Tyson puts considerable effort into understanding the nature of myth, particularly through the work of Paul Ricoeur. A mythos may or may not be true. For instance, reductionism has its own mythos. Originating particularly with Thomas Huxley (d.1895), this mythos contends that enlightened scientific truth has broken away from superstitious theological oppression, that scientists are "brave seekers of truth," whereas religious believers are hopelessly holding on to "vanishing pre-modern religious authorities" (pp. 157, 159). Nonetheless, "as is well understood by historians of science, Huxley's origin myth has no correlations with the actual history of modern science" (p. 159)—yet this is a myth which has proved enormously successful.

In contrast, Christianity's "true myth" is the Jesus story as God incarnate, crucified, resurrected, and ascended. Materialist-reductionist history, with its feeble capacity for high understandings, has, however, removed true myth from any sort of high understanding, fallaciously rendering "myth" a purely fictional category. Using Ricoeur's analysis of myth-types, Tyson then identifies the *pro*-historical Fall position as an instance of humanity's "mythos of the Fall," and identifies the *anti*-historical Fall position as an instance of humanity's "mythos of original violence" (because this parallels the scientific argument that the universe has always been violent). He then argues that the mythos of the Fall is necessarily the superior mythos, because "Adam and Eve and the fall in the garden of Eden are mythic truths for Christian theological epistemology" (p. 155).

How then does Tyson propose to reconcile this apparent discrepancy between Christian true myth, with its affirmation of a pre-lapsarian Eden, and the findings of science with regard to the continuous violent history of the universe and of *Homo sapiens*? Tyson says he does not know, and he does not feel the need to resolve the tension. His first truth is the biblical affirmation of a historical Fall:

> I have no interest in weighing in on the details of how the truth claims of our present natural history knowledge-constructs, within a reductively naturalistic set of interpretive commitments, may or may not be compatible with truth claims of an orthodox Christian belief in the fall of both humanity and nature. (pp. 144–45)

As he also puts it,

> I do not know how revealed myth relates to natural history and human historicity. On that plane, I am prepared to be firmly committed to *not* knowing rather than to assume Adam and Eve are historiographical and natural-history impossibilities. (p. 149, italics in original)

While this move to an intentional agnosticism is unexpected, at least to this reader, nonetheless "this lack of resolution should not be feared by Christians" (p. 156).

Tyson concludes with messages to two audiences. First, to reductionist materialists:

> The "natural light" of the post-lapsarian human knower is an inherently inferior theoretical framework for natural knowledge compared with

> knowledge that is theoretically integral with intrinsic, love-defined, grace-enabled empathetic and spiritually discerning Understanding. (p. 176)

But his ultimate message is directed to the overlappers, who should cease trying to adapt their theology to reductionist materialism as first truth and instead should "go on the front foot and reconfigure the interpretive lens of natural philosophy so that it is compatible with the first truths of Christian theology" (p. 176).

I will now comment on the many parts of his book that are to be appreciated, then move to discuss the parts about which I have concern.

Appreciation

The question of how to relate extra-theological knowledge claims (whether derived by rationality or the senses) to Christian belief is an ancient one. There is, for instance, the classic contrast between Tertullian, on the one hand (that "Jerusalem" [faith] has nothing to do with "Athens" [philosophy]), and Origen, on the other hand (with his blend of Christian faith and Neoplatonist philosophy); or there is the later contrast between Dominicans (with Aquinas's high view of post-Fall rationality), Franciscans (Scotus and Ockham, with their more limited assessment of humanity's inherent rational capacities), and Calvinists (with John Calvin's low view of post-Fall rationality).

During the age of emerging natural philosophy (the early Scientific Revolution), Christians continued to wrestle with this issue. For instance, Francis Turretin (1623–1687) argued for a view similar to Tyson's:

> Theology … is thus the judge and lord of all things, so that it judges concerning them and is itself judged by no other science; for all other disciplines must be examined according to [theology's] criteria, so that whatever [the disciplines] have that is not consonant with theology is to be rejected.[5]

The similarity to Tyson is not surprising, though, because Tyson is trying to recover for today the Christian first truth epistemology of that period.[6] Tyson is engaged in an important ancient Christian enterprise, one with which every generation needs to engage for its own times.

As already indicated, I find Tyson's book helpful at many levels. For one, I think framing his task within a Christian epistemology is correct: he gives a classical theistic justification of the general reliability of both our rationality and senses, tied to the nature of God; from this, the question of the place of science in Christian belief becomes a category within "Christian epistemology." This, however, is just another way of saying "the doctrine of Knowledge," and I prefer to use this term (rather than "Christian epistemology") simply to keep our understanding of epistemology accountable to the whole Christian doctrinal system. Nonetheless, Tyson's use of "awareness" to distinguish, yet integrate, both knowledge and understanding prompts me to think that maybe Christian theology should change "the doctrine of Knowledge" to "the doctrine of Awareness."

Then he provides his categories of first truth and second truth (perhaps inspired by Aristotle), which I find helpful for identifying and clarifying patterns of epistemic normativity: naming which concepts should be interpretively normative over other concepts. The actual content of Christian first truth is a matter we will return to below; nonetheless, the terms are heuristically helpful.

I also find very helpful Tyson's account of how the two truths came to be reversed. The story is, as he notes, far more complex than the overview he provides. Countless books have been written on the historical development of Western epistemology since the Scientific Revolution, although, in terms of the process Tyson calls "the great reversal," Charles Taylor's *A Secular Age* has set the standard.[7] For the wider Christian community, however, life does not provide time to digest many of these works, let alone Taylor's massive volume, so providing an accessible rendition of this history is a valuable service to the Christian community.

There are quibbles one could make with Tyson's telling of the story, but no history is exhaustive, and his account is well told. Indeed, I think it is important for all Christians in academia to have a basic grasp of this history, of how we got to where we are today. Naming this history helps us recognize that materialism is itself historically contingent; and naming materialism's own mythos serves to mythologize materialism precisely in order to then *de*mythologize it—by exposing materialism's own contingency and provisionality, thereby removing the mythic aura of unassailability that enshrouds it.

Following from Tyson's historical account of the great reversal, I also find helpful his retrieval of the Medieval theological principle (nominalism aside) that every part of creation possesses both physical and metaphysical properties; therefore, to truly understand any part of creation requires understanding the totality of its physical and metaphysical properties. There are, of course, distinctive methodologies for understanding physical versus metaphysical properties. Philosophical description of metaphysical categories can get quite complex (including such categories as causation, change, existence/essence, possibility/necessity, freedom/determination, wholes/parts, time, and so forth). Tyson, however, seems concerned with a narrower range of metaphysical properties: in particular, he names essence, meaning, purpose, aesthetics, value, and wisdom.

Regardless, the consequence of materialism removing such categories has been to atrophy both low and high understanding. This is seen in reductionism's instrumentalization and exploitation of nature, as well as in "scientists, academics, and policy makers often having no educated expertise in the terrains native to understanding" (p. 160). Consequently (and here is one of my favorite comments in the whole book), "We may have advanced beyond the Greeks in travel technology, from horses and wagons to jets, but we have not advanced beyond the Greeks in wisdom" (p. 170). For a marvelous work on this theme, I highly commend *Faith and Wisdom in Science,* by Christian physicist Tom McLeish.[8] I think, though, it would have been helpful if Tyson had named other harmful consequences from the removal of metaphysics. Further examples would significantly help readers, especially nontheologians, to understand the breadth of metaphysical reductionism's harm, and thus strengthened the overall importance of Tyson's project.

I also find Tyson's distinction between metaphysical reduction and functional reduction helpful. Tyson describes that part of the scientific task that Christians can share with materialists, namely, common-grace knowledge of nature:[9]

> The notion of reductive physical reality can be seen as a useful and partially truth-revealing abstraction. *As* God's creation, and *as* defined by Logos-infused natural "laws," truths about nature can indeed be grasped by viewing creation through the abstraction of a reductively physical lens. (p. 69; italics in original)

I see this as helpful not only on its own terms, but for a reason Tyson does not mention—namely, for discussions of whether Christians in the sciences should use the term "methodological naturalism."

This issue has been the source of previous discussion in this journal.[10] In contrast to these earlier *PSCF* contributions, Andrew Torrance argues that Christians should *not* use the term "methodological naturalism." Torrance (whose interlocutors include the earlier *PSCF* contributors) contends that the Christian's "scientific voice is inseparable from her faithful voice because she is committed to the pursuit of truth—truth that includes the nature and purposes of the Creator as well as the nature and purposiveness of the created."[11] To use "methodological naturalism" to describe how she does science risks conveying, even if unintended, a naturalist (materialist) interpretation of the object being studied. Moreover, the term should also be avoided, "lest she allow herself to become caught up in a culture that seeks to silence her discourse and blind her to what she has been given to recognize [by God]."[12] Similarly, Robert Larmer has recently argued that the term "exacts … questionable epistemological [and] metaphysical costs."[13]

To put this in Tyson's terms, for a Christian scientist to say they use methodological naturalism is to describe their task in terms set by materialist first truth, which inevitably carries a metaphysical value, namely that any object studied by methodological naturalism possesses no metaphysical properties. Then what terminology should Christians use? One possibility would be to replace "methodological naturalism" with Tyson's "abstractive functional reductionism." Nonetheless, one reviewer of this article (in earlier form) commented, "If one is seeking alternatives to the elocution 'methodological naturalism,' why not just stick with Tyson's 'natural science inquiry'? Because that's all methodological naturalism is." Within the back-and-forth of this terminological debate, to my ears this suggestion, "natural science inquiry," conveys with an attractive simplicity the desired sense of the scientific task undertaken with metaphysical neutrality.

Tyson's four-tier "integrative zone" is his central conceptual offering in the book. The high/low

understanding/knowledge distinctions are very helpful for alerting us to robust awareness of the different dimensions of Awareness. This prompts our attention to explore what it means for each of the four tiers to be integrated into the task of doing science. Indeed, Christians should make the case to materialists that nature possesses metaphysical properties. In this regard, Tyson makes an important point that how we conceive of science is socially constructed. This has been a standard observation in some secular academic circles for several decades.[14] Nonetheless, it is a principle often forgotten, and helpfully reiterated by Tyson, that,

> Science is not a natural object in the world that can be defined; rather, it is an ever-changing, historically situated, and culturally, philosophically, linguistically, and politically embedded human activity … [E]very way we have of knowing nature is in fact embedded in human culture and in our distinctive practices of living in the natural world. So, there is no reason why we should not do science differently. We can change our science. (pp. 90, 93)

The reason to change our science (that is, to change our reductionist-materialist presuppositions and interpretations of the findings of science) is precisely to recognize that nature possesses both physical and metaphysical properties. Nonetheless, Tyson recognizes that this will be an uphill battle with materialists, which he discusses in his final chapter.

Finally, I like Tyson's proposal for "ecclesially embedded intellectual communities, [which] could do science as integrated with the theoretical higher-wisdom insights of their religious traditions" (p. 173). To my ears, this sounds continuous with a comment from Barth: "The Christian can come to see the natural sciences as a discipline and vocation that is most at home in the life of the church—the community whose movements seek to track the fundamental reality of things."[15] I quite like this vision, though the cost of labs and equipment is so exorbitant, often many millions of dollars, I don't foresee churches making these sorts of expenditures, so I'm not sure what this would look like in practice. But I think it's an intriguing vision worthy of further exploration.

Constructive Critique

We come now to discuss what I see as the problematic portions of the book. I begin with the less substantive matters, simply to make the book's ideas more accessible. Then I move to more substantive comments.

Stylistic matters

As earlier mentioned, the book is principally aimed at theologians, but Tyson does try to make the book accessible to nontheologians. Beginning with chapter 7, however, the book becomes much more complex and difficult to follow. Looking at the book through the eyes of nontheologically trained readers, the material in section 7.5 ("Distinguishing and Integrating Natural Light and Divine Light," where he employs both medieval and Platonic ideas) and section 7.7 ("Ockham's Pincer") would particularly be a struggle. I think many readers would find it more helpful had Tyson simply presented his own four-tier framework (or "integrative zone") in chapter 7, and then moved his description of how he arrived at his framework from medieval and Platonic ideas into an appendix.[16]

Then I found the in-depth discussion of myth (sections 8.3–8.6) laborious. I have no problem with Tyson employing the mythos concept, and I understand why he provides this discussion (more below). Nonetheless, this was a section in which it was hard to see where the discussion was going; it could have used more cues to assist the reader—indeed, in my view the whole discussion of mythos could have been much more succinct. Moreover, the problem of seeing where the discussion was going remained throughout the latter chapters. Tyson is aiming the book at a readership that includes those who would benefit from a glossary, that is, those who are not used to reading at the philosophical level of Tyson's discussion. This readership would also benefit significantly from more transitional phrases to help them follow along, such as, "To recall what was said earlier in section 5.3 …"; or "To briefly summarize this part of the discussion so far …"; or "Here's where we are going with this …"

As well, I found some chapter and section titles unhelpful. Chapter and section titles set up the reader to expect the discussion to go in a certain direction, yet in some cases, it wasn't readily apparent to me how the subsequent discussion followed from the title. So, at times I found myself having to work to make the connection in order to feel I was accurately following the direction of his discussion.

I would add that in chapter 7, I found myself frustrated with his use of Greek letters (α, β, γ, δ) and Roman numerals (I, II) to identify particular categories in his framework/zone. Not that I have any inherent problem with Roman numerals or the first four letters of the Greek alphabet, but through the course of the discussion one has to remember which awareness category is assigned to which numeral or letter. Adjectival labels (such as "low knowledge" or "high understanding") are much easier for the reader to retain, and exclusive use of adjectival labels would have made this already-challenging chapter easier to follow. Tyson may object that ameliorating some of these concerns would have made the book somewhat pedantic. Perhaps so, for trained theologians, but not, I feel, for those outside the theological guild, such as practicing scientists.

We come then to Tyson's final chapter, "Recovering an Integrative Zone." Unfortunately, this chapter quickly became quite confusing for me as the chapter topics weren't making sense to me,[17] and it took me some time to figure out the reason. In his final chapter, Tyson expands the scope of what he means by "integrative zone." I would describe his earlier use of the phrase in chapter 7 as a *conceptual* zone, but in the final chapter (chapter 9), he turns to discuss what I would call a *cultural-institutional* zone—how to recover a place for equal consideration of Christian belief as a first truth within today's wider scientific world, including within educational institutions. Once this change in scope is recognized, the chapter topics fall into place. (Those interested in reading Tyson's book may find my 5,000-word summary as a helpful orientation before plunging into the book itself.[18])

Finally, I think readers would be significantly aided if Tyson had engaged, or at least referenced, the names and works of a wider range of contemporary figures. Tyson engages in any depth with only Plato, Aristotle, Aquinas, Augustine, and Ricoeur—only Ricoeur is not ancient. His critique, however, is explicitly directed at contemporary overlappers, yet he names only Polkinghorne plus "the Faraday Institute at Cambridge, and the work of ISCAST in Melbourne" (p. 84). The reader is left to guess to whom else he is addressing his critique—perhaps to McGrath, Deane-Drummond, Coakley, Barrett, or van Huyssteen? Although I agree with his Christian epistemology as far as it goes, it would have been enriched by engaging with other important recent figures, such as T.F. Torrance.[19] Engaging with a wider range of contemporary, or recent, figures would help readers more fully understand the content and breadth of the implications of Tyson's proposal.

The nature of first truth

We come now to the parts of Tyson's proposal that I found problematic. While I find the notion of first and second truths heuristically helpful, it seems to me that Tyson's application of them doesn't work. This is *not* to say they *can't* work—in fact, I share his direction of concern.[20] It's just that I don't think his method of getting there works.

How he identifies the content of first truth is problematic. He employs several different descriptions, each of which provides a different scope of content included in Christian first truth, the effect of which is to introduce unworkable ambiguities. Early in the book, he uses the terms "Christian creedal theology" and "Christian theology" to describe "first truth discourse" (pp. 4, 28) without defining either of them, but seeming to assume they are equivalents. This, though, raises the first ambiguity, for there is much in Christian theology that is not in the Nicene Creed, so these do not appear to be the same thing at all. "Christian creedal theology" seems to imply theology deriving just from the Nicene Creed, which seems considerably narrower in scope than "Christian theology," the latter implying the whole panoply of Christian doctrinal theology.

He also leaves undefined the question of who makes the decision for what counts as falling within the scope of either "creedal theology" or "Christian theology." In the latter case, for instance, *whose* articulation of full Christian doctrine counts? Melanchthon's one-volume *Loci Communes*? Francis Turretin's three-volume, 2,000-page opus? The 94-page *Christianity. Fundamental Teachings* recently published by the Christian churches in Turkey?[21] There are massive differences here in the content of what counts as "Christian theology." In effect, the concepts "Christian creedal theology" and "Christian theology" are simply too imprecise as guides for the purpose Tyson desires.

The ambiguities do not stop there, however. He adds a "minimal starting point" for Christian theology, namely five Christological truth-commitments from "Nicene orthodoxy"—the historical person of Jesus

as God incarnate, born of a virgin, crucified and died under Pontius Pilate, physically risen from the dead, and ascended to heaven. He calls these five beliefs "core doctrinal belief commitments" (p. 12). Note that this core is not the whole of the Nicene Creed, just the Christology of the creed. Yet he also speaks of "the primary interpretive commitments of Christian theology," in which he describes God's nature and relation to creation (though he does not name or discuss any other doctrines within this discussion of "primary commitments"). So, the Christology of the creed is "core doctrine" and the doctrine of God and God's relationship to creation is "primary interpretive commitment."

Tyson doesn't indicate what difference it makes that some beliefs within first truth discourse have the status of being "core," whereas other beliefs do not. Presumably, it must make some difference (otherwise why bother assigning "core" status to some doctrines?), but since he doesn't actually identify what the importance of being "core" is within either creedal or Christian doctrine, its function as core seems empty. Then several chapters later, Tyson identifies the Nicene Creed as a whole, not just its five-point Christology, as the criterion ("canon" and "rule") for orthodox faith (p. 92).

Then, we come to yet a further ambiguity, one between his terms "first truth" and "first truth *discourse*." The former sounds to my ears more precise, as if a fixed set of propositions or doctrines, whereas "first truth *discourse*" sounds to me intentionally more fluid—discourse conveys a sense of participants discussing possibilities around a topic, not setting boundaries. Indeed, I see no way to use "first truth" and "first truth discourse" synonymously. Discourse needs to be actual discourse, or discussion, *about* first truth—discourse can never *constitute* first truth.

So, Tyson's account of first truth turns out to be highly ambiguous, for its scope ranges from just the Nicene Creed as first truth (a very clear and limited set of propositions) to the whole range of Christian doctrine (though left undefined by Tyson). This massive breadth of scope just renders the content of Tyson's "first truth" unworkable. Tyson's task here, of doctrinal boundary setting, is an ancient one that the church has wrestled with throughout its history, but I don't see that his "first truth" proposal has advanced this effort.

The Fall and hermeneutics

To recall, the failure of overlappers to hold to a historical Fall is Tyson's central example of doctrinal acquiescence to science as first truth, for he says much stands or falls on this doctrine:

> [I]t is clear the Edenic myth cannot be meaningfully extracted [removed] from traditional and creedally orthodox Christian understandings of knowledge, as the category of the Fall is not only of basic soteriological significance but also of basic significance to Christian theology. (p. 103)

He later elaborates on this:

> If evil—at cosmic (devil), natural (death), and human (sin) levels—cannot be understood as exogenous [originating externally] to reality and as entering into the world in history … then the entire narrative of Christian salvation is profoundly incoherent … The truth of an Adamic Fall is [not] an optional component of a genuinely Christian understanding of cosmic meaning and the narrative arc of biblical salvation history. (p. 144)

Overlappers could argue, however, that Tyson overplays the importance of a historical Fall for protecting cosmic meaning, salvation history, and Christian epistemology. For even without a historical Fall, one's doctrinal system can include individual sin (people are still considered "fallen" in the sense of still rebelling against God), and it can include the same cosmic meaning, the same narrative arc of biblical salvation history on God's part, and the same theological epistemology. What would indeed change is one's account of biblical hermeneutics—how one interprets Genesis 1–3 and Romans 5:12–17. Remarkably, though, Tyson never engages in hermeneutical discussion. He makes just one hermeneutical comment, that the overlappers succumb to "the eighteenth century's historicization of biblical studies and its de-biblicizing trajectories in deist rationalism" (p. 103).

This, however, does not account for the overlappers' actual argument—that science itself shows a history of violence throughout the history of the universe and of humanity. Overlappers can readily argue that there is no inconsistency in holding the creed as first truth *and* holding to a nonhistorical Fall. This combination can still fully include the following: God's saving actions throughout Israelite history; God's saving action in the incarnation, resurrection,

and ascension of Jesus; the sanctifying work of the Holy Spirit; and the Christian eschatological vision for the second coming of Christ and a new creation. In effect, the consequences of a nonhistorical Fall are not "dire" as Tyson claims—indeed, it could be argued that the consequences are very positive for the task of faith seeking understanding, and for the persuasiveness of Christian faith in a scientific age.

The mythos of the Fall

In the face of the consequences of a nonhistorical Fall, how does Tyson respond? The usual response is hermeneutical, by discussing interpretive principles for the texts from Genesis 3 and Romans 5. But Tyson does not discuss scripture. Instead, his means of critique is to deploy the concept of *mythos*. This does come, at least to this reader, as a surprise—*mythos* is not a usual concept to employ as an argument against one's theological interlocutors. This could explain, though, why Tyson expands his notion of "first truth" to "first truth *discourse*," because "discourse" provides sufficient flexibility (or ambiguity) in his definition of "first truth" to import the concept of mythos as his means to protect a historical Fall—that the mythos of the Fall is superior to the mythos of original violence.

Overlappers will have at least two responses. First, as earlier observed, Tyson draws excessively dire implications that just don't follow. Here we can note one particularly egregious example, his comment that "once Western history and Christian myth become dissociated, that is, in fact, a very complete destruction of Christian theology" (p. 142). Really? Such a comment simply dismisses the substantial history of Asian and African theology produced apart from Western history. Despite his many comments throughout the book to displace Western hubris in light of indigenous ways of knowing, this comment sounds like just the sort of Eurocentric comment that elsewhere he is wanting to displace. But as a rhetorical flourish, it certainly conveys the sense of dire consequences he wants to convey. Overlappers are, however, unlikely to be persuaded.

Second, overlappers will find his categorization of them within the "myth of original violence" fallacious. While overlappers do contend that the eternal violence portion of the scientific story means there has never been an Edenic, nonviolent period in cosmic or human history, this does not mean that overlappers can be categorized by the mythos of eternal violence. By forcing this particular scientific claim (that the universe, the world, and humanity have always been violent) into the constraints of the "myth of original violence," Tyson misrepresents the scientific story held by overlappers: that is, in the story of the universe (including evolutionary biology), original violence is interwoven with equally original creativity, emergent complexity, cooperation, and beauty. Indeed, God has declared all this "very good." To force this whole story into the box of being a "myth of original violence" is to seriously misrepresent overlappers by labelling their multidimensional story by just one of its dimensions.[22]

In place of being categorized in this way, overlappers may well offer an alternate account of mythos as true myth, beginning from the observation that truth is as equally conveyed by figurative language as by literal language. We can recall that, on at least two occasions, Jesus corrected people for taking his language literally instead of figuratively.[23] That is, Jesus chose at times to use figurative rather than literal language to convey important truths. This allows us to distinguish between "figurative true myth" and "literal true myth," from which overlappers can argue that the Fall should be understood as "figurative true myth" rather than "literal true myth"—a possibility which Tyson doesn't address. In short, I don't see overlappers being convinced by Tyson's "inferior/superior mythos" argument.

Tyson's account of integration

What, then, is Tyson's methodology? It is, as is mine, one of integration. We both agree with Aquinas that truth must be a unity, and so, "In some way, Christian theology and a credible knowledge of the natural world must be capable of integration, or else one (or both) of them must be false" (p. 87; cf also p. 109).

Given that Tyson does not like the overlappers' proposal for how to integrate into Christian doctrine the findings of science with regard to the universe's eternal history of violence and destruction, then what is his proposal? Given his long discussion of the fourtier "integrative zone," one assumes he will explicitly apply this to the question. As it turns out, however, he intentionally *opts out* of demonstrating his method of integration, for he outright rejects integration in this case.

His rationale for this unexpected move is agnosticism combined with indifference. He states,

> I have no interest in weighing in on the details of how the truth claims of our present natural history knowledge-constructs, within a reductively naturalistic set of interpretive commitments, may or may not be compatible with truth claims of an orthodox Christian belief in the fall of both humanity and nature. (pp. 144–45)

A few pages later he repeats the point this way:

> So the fact that the fall must be historically and cosmologically impossible to materialistically reductive, naturalistically theorized science should be of no particular concern to Christians. (p. 154)

In other words, the claim that both the universe and humanity have always been violent is a product of materialism's metaphysical reductionism.

I am not opposed to saying, "Beyond here lies mystery because we see through a glass darkly." To illustrate this, we could cite Polkinghorne regarding the new Creation and scientific prognostication for the physical future of the universe:

> It is God's steadfast love that is the only ground of a true and everlasting hope …[24]

> [W]hat is ultimate is not physical process but the will and purpose of God the Creator. God's final intentions will be no more frustrated by cosmic death on a timescale of tens of billions of years than they are by human death on a timescale of tens of years. The ultimate future does not belong to scientific extrapolation but to divine faithfulness.[25]

Here Polkinghorne implies an agnosticism about *how* the long-term projections of science (about the universe's future death by expansion or by contraction) and God's future New Creation will be managed by God. In effect, Polkinghorne's theology moves from attempted explanation to agnosticism, and thus to simple affirmation of God's faithfulness. But Polkinghorne invokes his agnosticism after writing a whole book exploring the topic. That is, Polkinghorne does not invoke his agnosticism prematurely, whereas I would argue that Tyson does.

The reason is that, in my view, Tyson makes a category mistake. Present-day observations of constant destruction in the universe generally, along with continuous violence and death in biology/zoology, are instances of Tyson's low-knowledge/empirical-illumination category; and the logic that deduces that these processes have always been part of the universe (and of our planet, and of humanity) is an instance of his high-knowledge/rational(formal)-illumination category. Together these are *functionally* reductionist, not metaphysically reductionist, observations. That is, they are just the sort of common-grace, abstractive functional-reductive interpretations that Tyson affirms as providing useful and partially truth-revealing abstractions acceptable to Christians. Additionally, we recall his statement that "Christian theology and a credible knowledge of the natural world must be capable of integration" (p. 87). Well, the eternal violence of the universe (including in biology and by *Homo sapiens*) is as credible a part of knowledge of the natural world as one can find.

So, Tyson's decision to abstain seems inconsistent to me. Consequently, the task of integration, of seeking to understand how these pieces of low and high knowledge fit with the biblical story of the Fall, remains in place. Yes, the task of integration in this case is difficult, but I would argue it is no more qualitatively or substantively difficult than all the other sorts of complex questions that theologians address. As far as I can see, invoking agnosticism here means invoking agnosticism in countless other matters too, leaving the task of "faith seeking understanding" significantly atrophied. To take a parallel example from science, general relativity and quantum mechanics are both highly successful theories that have been tested and substantiated in countless ways. Every physicist believes they are both true—and yet the theories continue to contradict each other in significant ways. Nonetheless, despite this being such a perplexing problem, physicists don't abandon the problem, they continue to work hard to solve it. So, likewise, for the role of theologians when it comes to apparently contradictory perspectives in the Book of Nature and the Book of Scripture—our job is to continue seeking to understand how they belong together, even if we have to hold our proposals lightly.

Mythos and Plato as test cases

Tyson offers no other explicit test case by which to apply his four-tier integrative zone. He has, however, provided us with two implicit case studies: his use of "awareness" from Plato and "mythos" from anthropology. Surprisingly, Tyson does not identify either of these as examples of integration, yet that is precisely what they are. Unfortunately,

though, he fails to apply his creedal or creedal discourse test to either of them. In the case of Plato, and also Aristotle (whom Tyson also uses, though less centrally than Plato), Tyson does critically filter their ideas through Augustine and Aquinas. This, though, is not the same as testing Plato and Aristotle against the Nicene Creed or creedal theology—this is, rather, testing them against the thought of important Christian theologians. It is good to test Plato and Aristotle against Augustine and Aquinas, but within Tyson's schema this implies that Tyson is treating Aquinas and Augustine, and their respective corpuses, as equivalent to "first truth discourse." But if so, this just illustrates my earlier point that the category "first truth discourse," as a test for doctrinal acceptability, is unworkably large. And why stop with Aquinas and Augustine? Again we see the unsolvable problem of *which* theologians get counted as "in" or "out" as doctrine-defining authorities.

In the case of mythos, Tyson's justification for integrating mythos into his doctrine of knowledge is even more problematic and is limited to just two sentences: "any unified lifeworld must have its guiding mythos" (p. 132); and "mythic archetypes are a fundamental social reality" (p. 136). That's it. Yet, in light of 1 Timothy 4:7 ("godless myths"), many Christians would be unpersuaded that these two brief sentences succeed in justifying his use of "true mythos" as acceptable Christian language. They could contend that any use of "myth" attached to "truth" would potentially compromise the "truth" attached to it (similarly to Torrance's suggestion that Christians should avoid the term "methodological naturalism" because the word "naturalism" carries potential risk of theological compromise).

To be clear, I have no problem with using conceptual resources such as these from outside Christian faith, for Christian faith has always drawn—discerningly, critically, and provisionally—from extra-Christian conceptual schemes. The problem is that Tyson fails to meet his own methodological criterion—there is no discussion at all as to whether these extra-Christian ideas ("Awareness" and "mythos") fit with creedal first truth. Perhaps in Tyson's mind he believes they would pass the creedal test, yet for a book proposing that a theology of science requires first testing extra-Christian concepts against creedal first truth, or even "creedal theology," it is surprising and unfortunate that he fails to apply his own criterion.

In summary, when it comes to demonstrating his integration theory in practice, Tyson completely abstains from engaging with the one subject he explicitly raises (the Fall vis-à-vis current science). Then, in the cases of integration which he does engage in practice (mythos and Plato's awareness), he does not meet his own standard of first testing them against creedal first truth. Tyson offers no other examples by which to illustrate the application of his four-tier "integrative zone"; consequently, his "integrative zone" proposal ends up feeling theoretically potent but unclear, and disappointing, in actual application.

Antireductionist materialism

It is time to move our discussion from Christian doctrine to the challenge of materialism. Here I have a large concern: Tyson engages with materialist science only in its reductionist versions, but never identifies or discusses antireductionist materialism.[26] There have long been materialists who have recognized problems with reductionism and its cognate concept positivism, and this does seem to me a significant omission in the formation of a theology of science.

An early example of antireductionism is found in the *Einfühlung* tradition of J.G. Herder (1744–1803), which seeks understanding of cultures through *Einfühlung*—"feeling one's way into" the culture being studied, to understand that culture's values, relational patterns, hopes, rituals, relationship with nature, cosmology, and the like.

Much more influential than Herder, however, has been the antireductionism of the *Verstehen* tradition of sociology, stemming from Max Weber (1864–1920). This tradition distinguishes between *Erläuterung* (explanation) and *Verstehen* (understanding)—very similar to the distinction Tyson himself makes between knowledge and understanding. In the *Verstehen* tradition, "understanding" refers to the task of understanding social phenomena from the actor's point of view, treating the actor as a subject, rather than merely as an object of observation, thereby understanding a person's meanings, purposes, values, feelings, ultimate beliefs, and so forth that lie behind their actions.[27]

In other words, the *Verstehen* and *Einfühlung* traditions recognize many of the types of properties that Tyson wants included in richer low and high

understandings. The *Verstehen* tradition has had a great influence on both sociology and anthropology, making those disciplines alert to issues of low and high understandings. Similar principles are also seen in the positive psychology movement of recent times, as well as in the many university programs today researching "human flourishing." To pick one such example, the Greater Good Science Center, at the University of Califoria, Berkeley, researches and promotes such human properties as altruism, awe, compassion, forgiveness, purpose, and social connection.[28]

These examples are from the social sciences, because Tyson considers social sciences to be as reductionist as the natural sciences. Nonetheless, antireductionism exists in the natural sciences too, at both applied and theoretical levels. At the applied level, one can point to, for instance, the Oxford University TORCH/Shaping Destiny Project, which "brings together the fields of molecular biology and the arts."[29] Or, for another example, in 2017 the University of York, England, created a Chair in Natural Philosophy, in which the Chair spends 60% of their time working in physics and 40% in humanities, explicitly to bring the two fields together in mutual interaction.[30]

At the theoretical level, antireductionism arises in both the social and natural sciences through the concepts of *emergence* and *holism*.[31] These two closely related perspectives arose in the second half of the last century out of concern that the hyper-individualist methods of reductionist science do not account for wholes. *Emergence* is the idea that the physics of the universe at the big bang provided the content and processes for ever-greater complexity to emerge within the universe, bringing about the emergence of complex chemical, geological, and biological structures, right up to the immense complexity of the human brain and human societies. *Holism* is the idea that an object or group is greater than the sum of its parts, so that the parts interact and produce something more than what the individual parts can achieve on their own. It can be seen that the two concepts are closely related—holism results from emergence, and then holism provides conditions for further emergence.

While emergence and holism are prominent ideas today, they are nonetheless controversial, dividing scientists and philosophers alike—both the natural and social sciences today are divided between reductionists and emergentists/holists. Regardless, my point is that emergentism/holism is a prominent form of antireductionist materialism, opening the way for richer low and high understandings within materialism. In turn, this opens the way for the considerable amount of writing that has been published in recent years by materialist scientists on the meaning of life.[32] These writings do not carry the dour sense of meaning associated with the French existentialist philosophers Camus and Sartre. Rather, these are materialist accounts that point to hope, meaning, beauty, and goodness within the context of our place in a nonteleological universe. Unsurprisingly, holism contributes to anti-instrumentalist (i.e., pro-environment) views of nature, which are widely found among materialist scientists today.

All these are examples of materialists offering much richer low and high understandings than reductionists precisely because they take an antireductionist stance. Because these understandings do not include God or Christ or the Holy Spirit, they are not as robust as Tyson, or any of us as Christians, would want to see. Nonetheless, they do provide much fuller accounts of understanding than the reductionists.[33] From an antireductionist-materialist perspective, Paul Humphreys comments, in words that would warm Tyson's heart, "Scientific *understanding* provides a far richer terrain than does scientific *explanation,* and the latter is best viewed as a vehicle to understanding rather than as an end in itself."[34] In terms of religion, some antireductionists share with reductionists a desire to keep religion relegated to the private sphere, while other antireductionists, even if not religious themselves, see religion as contributing positively, at least on balance, to human well-being.

Why am I giving so much attention to antireductive perspectives in materialist science? For several reasons. For one, I think it is important that any theology of science provide an accurate account of the science about which it is theologizing. Of course, there will never be any perfect description of science—indeed, scientists and philosophers of science alike disagree on how to describe science. Nonetheless, we need to provide a defensibly comprehensive account. To write a theology of science that omits recognition of antireductionist materialism just seems too important an omission, for antireductionist materialism will unavoidably have implications for how we develop our theology of science.

For another, failing to recognize antireductionism affects both discipleship and evangelism. When bare reductionism is the only form of meaning offered by materialists,[35] Christian faith and hope can look much more attractive. But in light of antireductionism and its accounts of human flourishing and meaning, as well as its anti-instrumentalist interpretation of nature, Christian faith and hope have much stronger competition for the existential hearts and rational minds of people (as if it weren't already hard enough when there was just reductionism on the scene). If we describe science in purely reductionist terms, and we frame our responses to materialism solely through the lens of reductionism, then we do not have the conceptual tools either to prepare our own members for how to respond Christianly when they encounter antireductionist views, or to present a persuasive apologetic to seekers who are already shaped by antireductionism.

I have attempted precisely this task, of addressing these antireductionist materialist challenges, in *Freedom All the Way Up: God and the Meaning of Life in a Scientific Age*. Christian scientists Andrew Briggs and Michael J. Reiss have also attempted this in their book *Human Flourishing: Scientific Insight and Spiritual Wisdom in Uncertain Times*.[36] Nonetheless, too few Christians are working to address antireductionism, the best side of materialism's face. But getting more Christians engaged in this requires recognizing that materialism today comes not only in its reductionist mode but also in an antireductionist mode.

Theology of Science

Let us now return to the big picture. To recall, the full title of Tyson's book is *A Christian Theology of Science: Reimagining a Theological Vision of Natural Theology*. To reiterate an earlier comment, Tyson is not writing a theology of creation; he is, rather, writing a theology of the knowledge of creation. Nonetheless, the book's title overpromises. This is the result of the problem that triggers his theology of science project, namely, a specific epistemological concern about a specific group of people (the overlappers) whom he thinks are in epistemological error. This particular epistemological concern gives Tyson a precise focus for discussion, but ends up constricting his use of both theology and science.

His anti-overlappers agenda makes his use of science too narrow. This is not just in the sense of omitting antireductionism, but particularly, in the sense of focusing only on the *epistemology* of science. To repeat, his four-tier account of awareness, integrating low and high types of knowledge and understanding, is very helpful. In my view, though, a full theology of science would need to include other topics, such as a more comprehensive discussion of metaphysics. For instance, while the idea of "essence" is metaphysically essential for Tyson, current science is not supportive of the idea of essences—as, for example, in current philosophy of biology, where the concept of species was once considered an essentialist category but is now seen as very fluid (not due to postmodernism but rather due to advances in genetics). In the face of increasing anti-essentialism in science, a theology of science that employs "essence" needs to explain itself—not because it is bowing to materialism as first truth, but because it seeks to be understood and even persuasive. Moreover, while epistemology will obviously be a critical element within a theology of science, science is a complex human activity, and so a full theology of science needs to include attention to other important dimensions of science, including the sociology of science, the economics of science, the ethics of science, and science education.

Furthermore, Tyson's anti-overlappers agenda makes his use of theology too narrow. It is this agenda that leads him to employ the concept of first truth. This may be heuristically helpful for framing a response to the particular challenge of theological integrity in the science-and-faith context, but on its own, it is insufficient for a full-blown theology of science. A theology of science will potentially draw from systematic theology as a whole, from a larger portion of the full panoply of Christian doctrinal loci—creation, humanity, the Trinity, the church, salvation, redemption, mission, and so forth. At one point he does hint briefly at this need (for wider theological resources in the task of forming a theology of science), but he never raises this again; however, each of these loci will have implications for how we understand the tasks, methods, theorizing, sociology, and ethics of science. The content of creed, while central to the task, will not of itself achieve the theological richness of deploying a wider breadth of theological loci to the topic of science.

To give just one hint of this, the doctrine of revelation could draw on the ancient idea of the two books of revelation—scripture and nature. St. Augustine,

writing around 420 CE, provides an early version of this: "Some people, in order to discover God, read books. But there is a great book: the very appearance of created things. Look above you! Look below you! Note it. Read it."[37] Surprisingly, to my mind, Tyson never discusses this ancient interpretive frame of the two books of revelation, but I believe it provides an alternative methodology to that of Tyson. In effect, the ancient two books concept treats both books as first truths, meaning that they should be mutually interpreting, not related hierarchically one above the other. As one reviewer of this article (in earlier form) put it, Tyson "privileges special revelation over creation revelation, which is like saying that we have to privilege one of God's two revelations over the other rather than putting them in conversation with each other to learn as much as we can about God's good creation"—or even to compose a comprehensive, integrated story.

Furthermore, incorporating the doctrine of revelation into his theology of science would also require Tyson to address the place of hermeneutics in his proposal, since he consistently steers clear of hermeneutical discussions. Indeed, I would suggest that the heart of the issue lies not in competing types of mythos, but rather in the hermeneutics of Genesis 1–3 and Romans 5. The ancient "two books of revelation" tradition allows "mutual interpretation" to be part of the discussion of these specific texts; this, of course, opens the interpretive door to the overlappers. In effect, overlap methodology (and the "two books" tradition) need not be only a matter of illegitimate "religion-within-science" subservience, but also be a matter of faithful "religion-with-science" discernment. Regardless, I expect that the mutual interpretation principle of the ancient "two books" tradition means that Tyson would reject the "two books" tradition, just as he rejects another ancient principle, nominalism. He persuades me with regard to the latter, but not the former.

Other doctrinal loci will contribute new angles to a theology of science. Regardless, my larger point here is that the book is mistitled, thereby somewhat misleading the reader about what to anticipate. My suggestion would be *Reimagining a Theological Vision of Natural Knowledge: Prolegomena to a Christian Theology of Science*. I think this would capture more accurately what the book is about.

Conclusion

I have recommended Tyson's book to readers of this journal, indicating my own points of appreciation and critique. Here I would conclude with the words of Mark Mann: "[T]he scientific enterprise is in many ways sacred work, for it is the attempt to understand more fully the handiwork of God, and is in this way not unlike disciplined reading and discerning the Word of God in Holy Scripture."[38] So, too, thinking about the relationship of faith to science is sacred work. Despite various differences Tyson and I may have, our commonalities are far deeper, and so we share in the privilege of this sacred work. ☼

Notes

[1]"Autonomous overlap" is Tyson's term for their method; "overlappers" is my term of convenience, not Tyson's, for practitioners of this method.

[2]Joshua Swamidass, *The Genealogical Adam and Eve: The Surprising Science of Universal Ancestry* (Downers Grove, IL: IVP Academic, 2019).

[3]George L. Murphy, "The Twofold Character of Original Sin in the Real World," *Perspectives on Science and Christian Faith* (hereafter *PSCF*) 73, no. 3 (2021): 153, https://www.asa3.org/ASA/PSCF/2021/PSCF9-21Murphy.pdf.

[4]I would, though, modify some of Tyson's terminology. I don't believe "Existential Illumination" is really the right term to capture the properties Tyson assigns to low understanding (belief, theory, myth); I would suggest that "Conceptual Illumination" would be better. Likewise, I don't think "Rational Illumination" is the best choice to capture the properties of high knowledge, as the properties of low understanding (belief, theory, myth) are also highly rational; thus, I would replace "Rational Illumination" with "Formal Illumination," as mathematics, statistics, and logic (the content of this level of illumination) are often described in academia as the formal sciences.

[5]Francis Turretin (François Turretini), *Institutio Theologiae Elencticae, Pars I* (Geneva, Switzerland: Samvelem de Tovnes, 1679), 1, 6, 7. Cited by Karl Barth, *Church Dogmatics, Vol.1.1 The Doctrine of the Word of God*, ed. G. W. Bromiley and T. F. Torrance, trans. G. W. Bromiley, G. T. Thomson, and Harold Knight (London, UK: T&T Clark, 2009), 6. I have been unable to find this text in the English translation by G. M. Giger, though I have not sought the Tovnes edition to try to locate it through textual comparison.

[6]In his historical discussion, Tyson references a marvellous book of which I was previously unaware: John Henry, *Knowledge is Power: How Magic, the Government, and an Apocalyptic Vision Helped Francis Bacon to Create Modern Science* (London, UK: Icon, 2002). Henry recovers the critical role of faith for Bacon, which has long been denied by many historians. Henry also gives a wonderful, and surprising, explanation of what counted as "magic" back in the day, and why it played a central role for nearly all the early natural philosophers.

[7]Charles Taylor, *A Secular Age* (Cambridge, MA: Belknap Press, 2007).

[8]Tom McLeish, *Faith and Wisdom in Science* (Oxford, UK: Oxford University Press, 2014).

[9]Tyson defines "common grace" as "Gifts of God given to all humanity, be they saints, sinners, pagans, atheists, or even Australians" (p. 184).

[10]Robert C. Bishop, "God and Methodological Naturalism in the Scientific Revolution and Beyond," *PSCF* 65, no. 1 (2013): 10–23, https://www.asa3.org/ASA/PSCF/2013/PSCF3-13Bishop.pdf; Kathryn Applegate, "A Defense of Methodological Naturalism," *PSCF* 65, no. 1 (2013): 37–45, https://www.asa3.org/ASA/PSCF/2013/PSCF3-13Applegate.pdf; and Harry Lee Poe and Chelsea Rose Mytyk, "From Scientific Method to Methodological Naturalism: The Evolution of an Idea" *PSCF* 59, no. 3 (2007): 213–18, https://www.asa3.org/ASA/PSCF/2007/PSCF9-07Poe.pdf.

[11]Andrew B. Torrance, "Should a Christian Adopt Methodological Naturalism?," *Zygon* 52, no. 3 (2017): 719, https://doi.org/10.1111/zygo.12363.

[12]Ibid. Torrance engages with a line of other Christians on this topic—he specifically references C. Stephen Evans, Del Ratzsch, James K. A. Smith, Murray Rae, and Brad Gregory.

[13]Robert Larmer, "The Prohibitive Costs of Methodological Naturalism," in *Philosophia Christi* 24, no.1 (2022): 101–18, https://doi.org/10.5840/pc202224110.

[14]Paul Feyeraband is the classic figure here, but see also Nancy Cartwright, *A Philosopher Looks at Science* (New York: Cambridge University Press, 2022), chapter 2.

[15]George Hunsinger and Keith L. Johnson, *The Wiley Blackwell Companion to Karl Barth* (Hoboken, NJ: Wiley-Blackwell, 2019), 771.

[16]I recognize this problem precisely because this was a problem with my book *Freedom All the Way Up: God and the Meaning of Life in a Scientific Age* (Victoria, BC: Friesen, 2017). From the feedback I received after its publication, I should have provided a greatly simplified chapter 2 and moved the scientific-technical content of that chapter to an appendix. For those interested, that scientific content has since been revised and published as "God's *Agape*/Probability Design for the Universe," in *PSCF* 70, no. 3 (2018): 161–75, https://www.asa3.org/ASA/PSCF/2018/PSCF9-18Barrigar.pdf.

[17]Let me explain this confusion. Back in chapter 7, Tyson introduced the phrase "integrative zone" as the conceptual space where both knowledge and understanding exist and properly operate together, and in that same chapter he provides his four-tier proposal. In other words, by the end of chapter 7, the reader takes it that Tyson has recovered that integrative zone through his four-tier proposal. It is then confusing to arrive at his final chapter and find it titled "Recovering an Integrative Zone." I found myself thinking, "Hasn't he already recovered an integrative zone back in chapter 7? I guess not, or perhaps not sufficiently, otherwise he wouldn't be talking about it again. So, I presume in this chapter he is going to elaborate on the content of his four-tier proposal to complete the recovery." But then as I got into the chapter, the topics were about identifying problems with reductionist materialism ("Why hadn't he included this material in earlier chapters?") and about educational institutions ("Huh, what does this have to do with fleshing out his four-tier proposal?"). I couldn't put the section titles and discussions together with the chapter title.

[18]To receive this, please contact me at cjbarrigar@sympatico.ca.

[19]Importantly for their respective readings of history, Torrance views Duns Scotus as a hero for recovering contingency from Neoplatonism, but Tyson views Scotus along with Ockham as anti-heroes for their nominalism, which lead to Gassendian atomism and thus to contemporary reductionism.

[20]Here I will give an example of where I do see "first truth" and "second truth" working heuristically in practice. When I have taught epistemology, I discuss in class the nature of truth and the diverse accounts of truth on offer in the philosophical literature (correspondence, coherence, deflationary, and so forth). Then I offer my "Christian first truth" account. In materialist philosophy, the concept of "truth" is associated with propositions (linguistic [sentences] or formal [symbolic logic]), and so the materialist offers an account of truth attached to linguistic or formal propositions. Then I observe that scripture first places truth not in a proposition but in a *person*, who is also the *Logos* who created creation—"I am the way, the truth, and the life" (John 14:6). This, though, seems like nonsense to materialists: how can a *person* be truth? My contention is that Jesus is the truth because his character, words, and actions are directly tied to God and thus are *trustworthy* and *reliable*. Consequently, truth is *having the property of reliability*. Propositions therefore possess truth only derivatively, because God has created propositions to be able to reflect the *divine* properties of reliability and trustworthiness. (Note also how well this fits with Tyson's affirmation that our minds have "truth-carrying power" because God has created them.) From this "Christian reliabilist" account of truth, the Christian can then engage with secular accounts of truth—including worthwhile conversation with materialists about propositional reliabilism.

[21]This volume is actually a remarkable document. Under the pressure of living together in an Islamic context and needing to provide a unified face to the nation, the following churches, composing the Joint Commission of Churches in Turkey, published this document together in 2017: The Association of Protestant Churches in Turkey, The Catholic Bishops Conference of Turkey, the Syriac Orthodox dioceses of Turkey, the Armenian Patriarchal Surrogate in Armenia, and the Ecumenical Patriarch of Constantinople. That they have come together to produce such a document, albeit motivated by persecution, is a remarkable achievement within the scope of Christian history.

[22]Tyson rejects the mythos of original violence as Christian because of the moral consequences: "If we revert to this sort of cosmological outlook via a Hobbesian/Darwinian/Freudian naturalism, there cannot really be any such thing as a war crime, for violence, destruction, dominance, and death are primal and natural features of life and the human condition" (p. 140). Tyson is saying that these moral consequences apply to the overlappers because they fall within the mythos of original violence. But as indicated above, overlappers would reject the "original violence" category as their mythos, and thus reject these negative moral implications. Tyson also contends that for overlappers there can be no basis in the original goodness of creation, including of people, by which to ground the concept of human rights. The grounding of Christian human rights, however, should be in the doctrine of the

imago Dei, not in the original goodness of creation; the role of the latter is to show our responsibility to care properly for God's good creation. As well, because creation is good, and because people do rebel against God, the problem of evil remains for overlappers—it is not displaced for overlappers as Tyson contends.

[23]When Jesus said, "Beware of the yeast of the Pharisees" (Matt. 16:6,11–12), he had to correct his listeners that he wasn't literally meaning the actual biological, bread-raising yeast of the Pharisees; and when he said to Zacchaeus "You must be born again" (John 3), he corrected Zacchaeus's literal interpretation, that he had to be physically born a second time from his mother's womb.

[24]John Polkinghorne, *The God of Hope and the End of the World* (New Haven, CT: Yale University Press, 2002), 113.

[25]Ibid., 12. Note that this comment meets Tyson's "Christian first truth" criterion, even though Polkinghorne is Tyson's primary exemplar of a theologian who compromises Christian first truth.

[26]Sometimes the term "nonreductionist" is used in the literature. I would note that the terms "nonreductionism" and "antireductionism" are both partially fallacious from a Christian perspective, in that they still "reduce" God out of the picture.

[27]See Michael Martin, *Verstehen: The Uses of Understanding in the Social Sciences* (New York: Routledge, 2000).

[28]"What We Do," *Greater Good Magazine,* Greater Good Science Center at the University of California, Berkeley, accessed January 13, 2023, https://ggsc.berkeley.edu/what_we_do.

[29]"Shaping Destiny," TORCH: The Oxford Research Centre in the Humanities, https://torch.ox.ac.uk/shaping-destiny.

[30]"University Appoints Professor Tom McLeish to a Chair in Natural Philosophy," University of York, November 16, 2017, https://www.york.ac.uk/news-and-events/news/2017/research/mcleish-chair-york; and personal email correspondence with the Chair, Tom McLeish, November 2022.

[31]See Patricia Palacios, *Emergence and Reduction in Physics* (New York: Cambridge University Press, 2022); and Massimo Pigliucci, "Between Holism and Reductionism: A Philosophical Primer on Emergence," *Biological Journal of the Linnean Society* 112, no. 2 (2014): 261–67, https://doi.org/10.1111/bij.12060.

[32]For an overview, see Laura A. King and Joshua A. Hicks, "The Science of Meaning in Life," *Annual Review of Psychology* 72 (2021): 561–84, https://doi.org/10.1146/annurev-psych-072420-122921. See also: physicist Brian Greene, *Until the End of Time: Mind, Matter, and Our Search for Meaning in an Evolving Universe* (New York: Vintage, 2021); and physicist Max Tegmark, *Life 3.0: Being Human in the Age of Artificial Intelligence* (New York: Vintage, 2018).

[33]For an important example of a materialist social scientist building up from low knowledge to low understanding to high understanding, see Paul Thagard's three-volume series "Treatise on Mind and Society." The three titles (all 2019) are *Brain-Mind*: *From Neurons to Consciousness and Creativity*; *Mind-Society: From Brains to Social Sciences and Professions*; and *Natural Philosophy: From Social Brains to Knowledge, Reality, Morality, and Beauty* (New York: Oxford University Press).

[34]Paul W. Humphreys, "Analytic versus Synthetic Understanding," in *Science, Explanation, & Rationality: Aspects of the Philosophy of Carl G. Hempel,* ed. James H. Fetzer (Oxford: Oxford University Press, 2000), 201.

[35]See, for instance, "[D]eep down, we, like everything, are driven by purposeless decay," in Peter Atkins, *On Being: A Scientist's Exploration of the Great Questions of Existence* (New York: Oxford University Press, 2011), 20.

[36]Andrew Briggs and Michael J. Reiss, *Human Flourishing: Scientific Insight and Spiritual Wisdom in Uncertain Times* (Oxford, UK: Oxford University Press, 2021).

[37]Sermon 126.6 in the Angelo Mai collection, *Miscellanea Augustiniana* 1, ed. G. Moran (Rome, 1930), 355–68, cited in Vernon Bourke, trans. *The Essential Augustine* (Indianapolis, IN: Hackett, 1974), 123.

[38]Mark H. Mann, "The Church Fathers and Two Books Theology," *BioLogos*, November 4, 2012, https://biologos.org/articles/the-church-fathers-and-two-books-theology.

Culture and the Big Questions

DOI: https://doi.org/10.56315/PSCF3-23Laats

CREATIONISM USA: Bridging the Impasse on Teaching Evolution by Adam Laats. New York: Oxford University Press, 2021. 218 pages. Hardcover; $32.95. ISBN: 9780197516607.

Historian Adam Laats (a self-described noncreationist, nonscientist) has written a thorough and well-documented account of American creationism, past and present. His frequent use of primary literature and direct quotes assures the reader that s/he is being presented with accurate information.

Laats shows that most Americans don't know much about evolutionary theory and that they have taken the path of least resistance by carelessly embracing positions simply because of the persuasiveness of winsome idea champions. Latts argues that they should evaluate supporting evidence for those positions. He opposes the "missionary attitudes" on both sides of the controversy, pointing out that some creationists link views on origins with salvation, and some atheistic evolutionists wish to convince creationists to abandon religion for science.

Laats posits that the evolution/creation conflict is mostly between young earth creationists (YEC), whom he calls "radical creationists," and everyone else. He says that radical creationists incorrectly conflate the holding of "liberal" social positions on such things as sexuality, abortion, and politics with learning about evolution. In response, radical creationists have built systems and institutions to promulgate their views in competition with mainstream science. Sadly, his use of the harsh moniker "radical creationists" will not lead many YEC adherents to read his book.

Laats theorizes that creationists are such for many reasons, including seeking explanations of first cause, purpose, and the driving forces acting in the created order. He points out that they are also concerned about consciousness and morality. While he gives examples of the uncivil and fratricidal rhetoric between champions of various creationist positions, he also takes the time to describe the hermeneutical approach taken by a majority of YECers (famously promoted by Ken Ham and his ministry Answers in Genesis), that is, to understand the intended meaning of the biblical text under consideration. He then shows that while the old earth creationist perspective (championed by Hugh Ross and the ministry Reasons to Believe) is quite varied in the particulars, it agrees with the YEC view that speciation events were acts of divine intervention, not evolution. He continues to show that mainstream evolution gains the strongest support from creationists self-identified as evolutionary creationists (i.e., theistic evolutionists), who are represented by the "non-radical" umbrella organization BioLogos. He shows that intelligent design proponents hold diverse views on the age of the creation and on evolution, but that they share the belief that life is too complex to have arisen on its own. With keen insight he writes: "Radicals, non-radicals, old earthers, intelligent designers, evolutionary creationists all compete to have their creationist vision embraced by religious people who might or might not look askance at evolutionary theory" (p. 17).

While he thoroughly describes the main creationist viewpoints (young earth creation, old earth creation, evolutionary creation, intelligent design), and he quotes evolutionary creationist Kenneth Miller statement that "absolute materialism … cannot fully explain the nature of reality" early on (p. 21), for the rest of the book, Laats largely ignores how naturalism, materialism, and teleology affect theists' stances toward evolutionary theory.

Naturalism (ontological) is the view that the universe completely lacks supernatural or metaphysical elements.[1] While many evolutionary creationists are methodological naturalists (science should not address metaphysics), they are not ontological naturalists.

Materialism, while similar to naturalism, posits that the universe consists only of matter and energy.[2] Relating these propositions to science, David Griffin writes:

> Science, it is widely agreed in scientific, philosophical, and liberal religious circles, necessarily presupposes naturalism … Most philosophers, theologians, and scientists, however, believe that scientific naturalism is incompatible with any religious view of reality.[3]

Teleology (biological progress) is consistent with the theological view that God created the universe and life with purpose.[4] Evolutionary creationists hold a variety of views on teleological evolution, and those who accept it in principle disagree on possible mechanisms of action. Many creationists conflate evolution, materialism, and ateleology. This strengthens their resolve to reject evolutionary theory of any kind.

To "bridge the impasse," Laats prescribes how evolution should be taught in public secondary schools: children should learn about evolution and religious ideas should be kept out of the classroom. Trust in educators should be fostered because Americans doubt mainstream evolutionary theory due to "our fundamental, divisive, enduring lack of trust" (p. 175). But this approach to gain trust of students through the presentation of convincing evidence and arguments has already been shown to be largely ineffective. Teachers

who fail to consider religious presuppositions are likely to build intransigence among their religious students. On the other hand, culturally competent teaching methods have been shown to successfully engage both evolutionary theory and the learner's presuppositions and religious beliefs. A growing body of empirical studies shows that culturally competent evolution educators can gain the trust of their students, who are then less resistant to new or previously rejected propositions about evolution.[5]

In summary, this fine book suffers from a failure to recognize naturalism/materialism as the core conflict between creationists and materialistic evolutionists,[6] and it doesn't promote the building of trust and reconciliation in educational settings through culturally competent evolution instructional methods.

Notes

[1]David Papineau, "Naturalism," in E. N. Zalta, ed., *The Stanford Encyclopedia of Philosophy* (Summer 2021 Edition), https://plato.stanford.edu/archives/sum2021/entries/naturalism/.

[2]William Jaworski, "Why Materialism Is False, and Why It Has Nothing To Do with the Mind," *Philosophy* 91, no. 2 (2016): 183–213, https://doi.org/10.1017/S0031819116000036.

[3]David Ray Griffin, *Religion and Scientific Naturalism: Overcoming the Conflicts* (Albany, NY: SUNY Press, 2000), 11.

[4]Sy Garte, "Telelogy and the Origin of Evolution," *Perspectives on Science and Christian Faith* 69, no. 1 (2017): 42–50, https://www.asa3.org/ASA/PSCF/2017/PSCF3-17Garte.pdf.

[5]For example, M. Elizabeth Barnes and Sara E. Brownell, "A Call to Use Cultural Competence When Teaching Evolution to Religious College Students: Introducing Religious Cultural Competence in Evolution Education (ReCCEE)," *CBE—Life Sciences Education* 16, no. 4 (2017), https://doi.org/10.1187/cbe.17-04-0062.

[6]See M. Elizabeth Barnes et al., "'Accepting Evolution Means You Can't Believe in God': Atheistic Perceptions of Evolution among College Biology Students," *CBE—Life Sciences Education* 19, no. 2 (2020), https://doi.org/10.1187/cbe.19-05-0106.

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DAWN: A Proton's Tale of All That Came to Be by Cees Dekker, Corien Oranje, and Gijsbert van den Brink. Translated by Harry Cook. Downers Grove, IL: InterVarsity Press, 2022. 166 pages, discussion questions. Paperback; $22.00. ISBN: 9781514005668.

Imagine that you could witness the entire history of the universe first-hand, from the big bang to the end of time. Perhaps, if you were a sentient yet patient proton, you would have the necessary longevity and attention span, and this idea could become your reality. Such is the premise of *Dawn: A Proton's Tale of All That Came to Be*. "Pro," as the proton protagonist is known to his chatty neighboring subatomic particles, is born from quarks in the first second after the big bang, blind and knowing nothing, but with an insatiable curiosity about what is happening, and why. Conversations with other particles born a split-second earlier soon produce in Proton a deep admiration for a skilled Creator, and a sense of wonder and anticipation about what they have seen and what will happen next.

Throughout several chapters, Pro confusedly and vividly experiences the onset of light, nuclear fusion, a supernova, and incorporation into a molecule as part of a carbon nucleus. Pro ends up in the dust cloud that forms Earth, eventually witnessing the origin of terrestrial life as part of an RNA molecule. A rumor among the subatomic particles that the Creator wants to make personal contact with one of the creatures generates a guessing game as they witness the progress of evolution. Which lifeform will it be?

When *Homo sapiens* arrive on the scene, the story shifts to tracking biblical narratives, and the subatomic particles begin asking each other more theological questions. The Creator makes contact with two humans, a chieftain couple in Africa. The Fall ensues when the couple and their tribe reject the Creator's instructions, much to the subatomic particles' surprise and horror. Pro and his neighbors are then able to witness key moments in the progress of redemption, becoming fly-on-the-wall observers to events in the lives of several important biblical characters. "How is the Creator going to fix things?" the particles ask each other.

At this point it becomes apparent what a colossal challenge the three authors (a nano scientist, a novelist, and a theologian)[1] have taken upon themselves. They have tried to produce a gripping narrative in which the protagonist does not know the outcome, but Christian readers will. They have set out to tell an entertaining story of the history of the universe from a Christ-centered perspective, filled with imaginative details that are consistent with modern science but also with the biblical witness. They have charged into a literary no man's land between fiction and nonfiction.

Do they succeed? In many ways, admirably so. The merging of science and biblical witness is skillfully accomplished, respecting the integrity of each source of knowledge. To readers of this journal, the idea of a Creator patiently guiding the evolution of the universe and of life over billions of years in order to generate Earth and its humanity, followed by the increasingly intimate involvement of that Creator in redeeming humanity, is familiar. To many others, this idea will be revelatory.

If evaluated as a work of fiction, it would be safe to say that *Dawn* is wildly imaginative, yet it is also strangely hindered by the passivity of the narrating subatomic particles. "Imagine that you yourself could determine where you would like to go" (p. 28), they muse just before the first protocell develops. Pro witnesses and experiences history but cannot intervene. The subatomic particles can react, but they have no agency in the macroscopic world. They do not embark on a quest or a voyage of self-discovery. "Just go with the flow" (p. 29), one advises. The tropes of fiction, however, are probably the wrong standards for evaluating this book.

Dawn succeeds, in the end, as creative nonfiction—the memoir of a proton. Along the way, it retells the old, old story in an imaginative way. The authors have created one of the most accessible books on science and Christianity to come out in recent years. Even young adults will be able to enjoy it.

Note

[1]Cees Dekker, distinguished nano-scientist at Delft University of Technology; Corien Oranje, novelist/theologian and author of Christian children's literature; and Gijsbert van den Brink, theologian and holder of the Chair of Theology and Science, Vrije Universiteit Amsterdam.

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FRACTALS: The Secret Code of Creation by Jason Lisle. Green Forest, AR: Master Books, 2021. 224 pages. Paperback; $29.99. ISBN: 9781683442400.

Fractals: The Secret Code of Creation, by Jason Lisle, is a beautifully crafted coffee-table book which invites readers not only to the beauty of mathematics, but also to belief in Christianity. The author is affiliated with Answers in Genesis and is a founder of the Bible Science Institute, both of which insist on a young earth interpretation of Genesis 1–3.

The mathematical chapters are well written, but the book is really an apologetic for a narrow Christian worldview. The book claims that mathematics, particularly the Mandelbrot fractal and similar objects, displays God's nature. The first chapter, "The Secret Code," claims that "those who reject God like to explain the complexity of biological life by appealing to Darwinian evolution," but that mathematics is free from this "because numbers do not evolve." The fractals in this book, beginning with the Mandelbrot set, give an "infinitesimal glimpse into the mind of God" (p. 9). This sets the theme: there are only two worldviews, and these are in direct competition. The mathematics of fractals is to lead the reader toward the Christian worldview, indeed to a "secret code."

A computer-generated example of a fractal, introduced by Benoit Mandelbrot,[1] is created in the complex plane by iterating the quadratic function $f(x)=x^2+c$. Pick a complex number c and examine the sequence c, $f(c)$, $f(f(c))$, and so on. Ask the question, "Do these iterates of the function form a bounded sequence?" If the sequence is bounded, then the complex number c is in the Mandelbrot set. In the complex plane, color that point, c, black. If the sequence c, $f(c)$, $f(f(c))$, … is *not* bounded, give c a color based on the speed of growth of the sequence. Use a modern computer to color the points in the complex plane. With this coloring, the mathematical analysis of the Mandelbrot set gives rise to intricate paintings of the complex plane.

After this introduction, the book describes the required mathematical material: sets, complex numbers, function iteration. The mathematical descriptions are well done and intended for a popular audience. There are no frightening equations to drive away the reader. The prose, along with the accompanying artwork, is inviting. One might use much of this book as an invitation into the study of mathematics. Indeed, many mathematicians have used the study of fractals to do just that.

Chapters two through seven explore the mathematics of the Mandelbrot set with text-printed elegant pictures of various regions of the fractals. Chapters two through five, with picturesque titles—"Valley of the Seahorses," "Valley of the Double Spirals," "Infinite Elephants, Scepters on Seahorses"—focus on a particular region of the Mandelbrot set, zooming in to display intricate spirals, bays, peninsulas. The infinite complexity of these drawings is beautiful and agrees with my belief that mathematics is the language of the great artist.

The sixth chapter, "Changing the Formula," asks what happens if the simple quadratic $f(x)=x^2+c$ is replaced by other quadratics. It is shown, by examples, that other quadratics merely transform the Mandelbrot set, shifting it in some obvious manner. A mathematics student comfortable with function transformations will recognize that any quadratic function can be transformed into any other quadratic—this is the essence of the quadratic formula—and so it should not be surprising that nothing new is achieved by replacing one quadratic by another.

Later chapters replace a quadratic function by other polynomials, then by functions involving fractional exponents, then by a conjugate function and finally by trigonometric and exponential functions. Euler's marvelous identity $e^{i\theta}=cos\theta+i\,sin\theta$ briefly comes into play, linking trigonometric and exponential functions in the complex plane. In all these chapters, the mathematical explanations are kept simple, and the beautiful artwork continues. The chapter, "Geometric and 3D Fractals,"

asks about higher dimensional figures and introduces the quaternions. The chapter does not go deeply into the material but intends to leave the reader curious and intrigued. The concluding chapter describes occurrences of fractals as physical objects in nature (shorelines, clouds, trees, etc.), returning to the topic found in Mandelbrot's introductory book.

Chapter 8, "Fractals and the Christian Worldview," is an interlude to the mathematics, returning to the claim that of the two suppositions, a Christian or a non-Christian worldview, only the Christian worldview truly explains fractals. Yes, the infinite complexity of the Mandelbrot set is beautiful. Many mathematicians agree that beautiful objects like this are independent of human thought, a form of mathematical *platonism*. But the leap from mathematical *platonism* to belief in a creator and then to belief in the biblical God is not well supported by Lisle. He ignores the difficulties involved in these steps: first from mathematical *platonism* to deism, and then from deism to belief in the God that Christians worship.

In the final (twelfth) chapter, Lisle returns to his argument that mathematics points to the God of the Bible. He quotes physicist Eugene Wigner's article, "The Unreasonable Effectiveness of Mathematics in the Natural Sciences," which discusses the "miracle" of mathematics in explaining the modern world.[2] Lisle then quickly dismisses other religious views and claims that only the Bible makes sense of our universe. The book ends with a gospel presentation.

One can argue (Rom. 1:20) that God's divine nature is visible in the beauty of mathematics, but Lisle quickly dismisses the beliefs of atheists and non-Christian religions and leaps to claiming (as implied by the book's subtitle) that the *only* legitimate reaction to fractals is to believe in the Christian God. While most of my mathematical colleagues identify with mathematical *platonism*, their beliefs vary across a spectrum from atheism/agnosticism through Judaism, Islam, and Christianity. The jarring leap from "the beauty of fractals comes not from people" (p. 125) to the Christian worldview, will leave a thoughtful skeptic with whiplash. At no place is the "secret code" to creation explained explicitly.

Lisle's approach to apologetics is that of presuppositionalism. He assumes that only a Christian worldview is reasonable. However, presuppositional apologetics has several significant flaws. It can quickly become a circular argument: if one assumes the truth and accuracy of the Bible as an axiom then the Christian worldview is a foregone conclusion. This approach receives quick approval from people who already believe the scriptures but is readily dismissed by the sceptic. Even when the circular argument is avoided, the best one can argue is that the universe—and mathematics—appears to be beautiful, appears to have design. The appearance of design is roughly equivalent to mathematical *platonism* and parallels the argument of Romans 1. But the sceptic who accepts this argument will immediately point out that there are many worldviews that begin with this assumption. The leap to the Christian worldview is not proven by this approach; it requires the additional confirmation of special revelation.

In other publications, Lisle rejects both the big bang theory and evolution. Ironically, this beautiful book on fractals makes it clear that elegant and complex structures do indeed arise from quite simple processes. This is a concept that underlies the theory of evolution, which Lisle opposes.

Would I put this book on my coffee table? No, because ultimately this book is an attempt at apologetics. The flaw in the apologetics will be apparent to the thoughtful sceptic. And the author's attempt to establish the Christian worldview includes simplistic claims that are dismissive of people with other beliefs.

Notes

[1]Benoit B. Mandelbrot, *The Fractal Geometry of Nature* (New York: W. H. Freeman, 1982).

[2]E. P. Wigner, "The Unreasonable Effectiveness of Mathematics in the Natural Sciences," *Communications on Pure and Applied Mathematics* 13 (1960): 1–14.

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History of Science

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GENERATIONS OF REASON: A Family's Search for Meaning in Post-Newtonian England by Joan L. Richards. New Haven, CT: Yale University Press, 2021. 456 pages, with 21 b/w illustrations, 1,218 endnotes, and a 35-page index. Hardcover; $45.00. ISBN: 9780300255492.

The title gives no clue who this book is about. Nor does the publisher's description on its website, the abbreviated blurb inside the book jacket, the four endorsements posted on the jacket's back ("beautifully written," "epic masterpiece," "magnificent study," "compelling and wide-ranging"), or even the chapter titles. The reader first learns whom the book is about and how it came into focus in the author's Acknowledgments. In studying the divergent interests of Augustus De Morgan and his wife, Sophia, the importance of De Morgan's father-in-law William Frend's thinking became apparent. This is turn led Richards to delve into the lives and beliefs of two ancestors from the previous generation, Francis Blackburne and Theophilus Lindsey, who felt compelled by their commitment to "reasoned conclusions about

matters of faith" (p. x) to move away from orthodox Anglicanism and establish the first Unitarian church in England. Thus the book eventually evolved into chronicling the lives of three generations over a century and a half during (roughly) the Enlightenment era.

A central motif running through the experiences, beliefs, and work of these families was their steadfast commitment to a form of enlightened rationality that provided coherence and foundational meaning for their lives. Reason informed their ecclesiastical commitment to Unitarianism, their views of science and mathematics, and their public activity favoring social and educational reforms. But also, paradoxically, their search for reason led to the beliefs and practices (of some family members) that today would be considered pseudo-scientific—mesmerism, phrenology, and spiritism, among others.

As Richards notes in the book's opening sentence, for her, *Generations of Reason* is "the culmination of a life devoted to understanding the place of mathematics in modern European cultural and intellectual history." The mathematics and logic of early- to mid-nineteenth-century Britain has been an ongoing research interest for Richards during her forty-year tenure as a historian of mathematics at Brown University. It is this that largely drew me to the book and which I will focus on here: it climaxes in a substantive treatment of the progressive mathematics of De Morgan, whose work contributed to transforming British algebra and logic. This is in stark contrast with the radical ideas of Frend, who refused to admit negative numbers into mathematics.

A central figure behind the developments under investigation is John Locke, whose *Essay Concerning Human Understanding* (1689) and *The Reasonableness of Christianity, as Delivered in the Scriptures* (1695) exercised a tremendous influence over and challenge for eighteenth- and nineteenth-century British thinkers. Locke's ideas defined and emphasized rationality in relation to knowledge generally and to scientific and religious knowledge in particular, providing dissenters with a rationale for combatting traditional theology and conformist science and philosophy. For Locke, however, a literal reading of Scripture was still authoritative for religious beliefs. This was true for Frend and De Morgan also, even though they held tolerant attitudes toward a wide latitude of thinkers.

Locke's view of reason also affected period reflections on mathematics. Like others in the early modern and Enlightenment eras, Locke had held up mathematics as a model of absolutely certain knowledge because of the clarity of its ideas and the supposed self-evidence of its axiomatic truths. Of course, this characterization applied more to Euclidean geometry than to the burgeoning domains of analytic mathematics, such as calculus, which, as Berkeley charged, still lacked a sound theoretical basis. As for logic, Locke had an acute antipathy toward traditional argument forms and proposed that one should reason with ideas rather than words, assessing their agreement or disagreement in less convoluted ways than in a syllogism. In expressing such relations with language, though, one should use meaningful and unambiguous terms. This was somewhat problematic in algebra and calculus, where symbolic expressions were manipulated to produce useful and important results, even when their meaning was less than clear.

Around the turn of the nineteenth century, Frend campaigned to bring algebra in line with Lockean reasoning: algebra was conceptualized at that time as universal arithmetic, containing such laws as the transposition rule *if* $a+b=c$ *then* $a=c-b$. Thus, no expression should be employed if its meaning was unintelligible. In the above equations, one must assume the condition $b<c$ to rule out negative values, since numbers, which represent quantities of discrete things, cannot be less than 0. Excising negative quantities from mathematics was extreme but necessary in order to adhere to a literalistic view of rationality.

British mathematicians largely resisted following Frend down this path of purity, though they were unsure how to rationally justify their use of negative and imaginary quantities without going outside mathematics and appealing to things like debts. Robert Woodhouse, in an 1803 work, was one of the first Cambridge mathematicians to propose a more formalistic algebraic approach in calculus. This agenda was furthered a decade later by members of Cambridge's Analytical Society, one of whom was George Peacock. His and others' attempts to convert Cambridge analysis from Newtonian to Leibnizian calculus were waged through translating a French textbook and making notational changes in Cambridge's mathematical examinations.

In 1830 Peacock's *Treatise on Algebra* introduced a more formalistic approach in algebra. Richards argues, drawing upon some fairly recent research, that Peacock's position was grounded in a progressivist view of history: arithmetic developed naturally out of fluency with counting, and algebra out of familiarity with arithmetic. Arithmetic suggests equivalent forms (equations, or symbolic assertions like the above rule) that can also be accepted as equivalent/valid in algebra without being constrained by restrictions appropriate to arithmetic. Such transitions, he thought, constitute genuine historical progress. Algebra thus splits into two parts for Peacock, arithmetical algebra and symbolical algebra, the latter based upon his principle of the permanence

of equivalent forms, as found in his 1830 *A Treatise on Algebra*.

Peacock's approach to algebra set the stage for later British mathematicians such as De Morgan (Peacock's student), Boole, and others. Initially inclined to follow his future father-in-law's restrictive approach in algebra, De Morgan was soon won over to Peacock's point of view, even going beyond it in his own work. In a series of articles around 1840, De Morgan identified the basic rules governing ordinary calculations, but he also began entertaining the notion of a symbolical algebra less tightly tied to arithmetical algebra. By more completely separating the interpretation of algebra's operations and symbols from its axioms, symbolical algebra gained further independence from arithmetic. This gave algebra more flexibility, making room for subsequent developments such as the quaternion algebra of William Rowan Hamilton (1843) and Boole's algebra of logic (1847).

After exploring the foundations of algebra, De Morgan turned his attention to analyzing forms of reasoning, a topic made popular by the resurgence of syllogistic logic instigated at Oxford around 1825 by Richard Whately. Traditional Aristotelian logic parsed valid arguments into syllogisms containing categorical statements such as *every X is Y*. De Morgan treated such sentences extensionally, using parentheses to indicate total or partial inclusion between classes *X* and *Y*. Thus, every *X* is *Y* was symbolized by *X*)*Y* since the parenthesis opens toward *X;* to be more precise, one should indicate whether *X* and *Y* are coextensive or *X* is only a part of *Y*. By thus quantifying the predicate, as it was called, De Morgan allowed for these two possibilities to be symbolized respectively by *X*)(*Y* and *X*))*Y*, in compact symbolic form as ')(' and '))'. Combining the two premises of a syllogistic argument using this notation, one could then apply an erasure rule to draw its conclusion. De Morgan enthusiastically elaborated his symbolic logic by adopting an abstract version of algebra that paved the way for operating with formal symbols in logic. De Morgan's symbolism is not as inaccessible as Frege's later two-dimensional concept-writing (though the full version of De Morgan's notation is more complex than indicated here), but it is still rather forbidding and failed to find adherents.

In addition to expanding Aristotelian forms by quantifying the predicate, yielding eight basic categorical forms instead of the standard four, by 1860 De Morgan was generalizing the copula "is" in such sentences to other relations, such as "is a brother of" or "is greater than." He began to systematically investigate the formal properties of such relations and the ways in which relations might be compounded. Though intended as a way to generalize categorical statements and expand syllogistic logic, his treatment of relations was later recognized as an important contribution that could be incorporated into predicate logic. Richards's treatment gives the reader a fair sense of what De Morgan's logic was like, and while a detailed comparison is not developed, the reader can begin to see how De Morgan's system compares to Aristotelian logic, Boole's algebra of logic, and contemporary mathematical logic.

However, as indicated at the outset, exploring De Morgan's algebraic and logical work is only a subplot of Richards's story. Her book is principally a brief for how reason grounded the work and lives of several significant thinkers in an extended family over three generations. As she ties various threads together, the reader occasionally senses that the presentation may be too tidy, drawing parallels between vastly different developments to make them seem of a piece, all motivated by the same driving force of reason. Nevertheless, Richards's account forces the reader to continually keep the bigger picture in mind and to connect various facets of the actors' lives and work to their deeper commitment to reason. Her book thus offers a commendable case study for how technical trends in mathematics might be tied to broader cultural and philosophical concerns.

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OF POPES & UNICORNS: Science, Christianity, and How the Conflict Thesis Fooled the World by David Hutchings and James C. Ungureanu. New York: Oxford University Press, 2022. 263 pages. Hardcover; $39.95. ISBN: 9780190053093.

Readers of *PSCF* are familiar with the "warfare thesis" for the history of science and religion. This interpretation, framed as a historical analysis that stretches from the ancient Greeks to the modern period, explains the way in which science and religion have always been in conflict with each other. At the center of this interpretation are John William Draper's *History of the Conflict between Religion and Science* (1874), and Andrew Dickson White's *A History of the Warfare of Science with Theology in Christendom* (1896). Since the publication of these books, numerous professional historians as well as the general public have accepted and perpetuated many of the claims made within them. The problem with this line of interpretation, however, is that Draper and White were often wrong. For instance, Christopher Columbus (and people in the medieval period) did not think the earth was flat. Christians did not oppose anesthesia. There was no Dark Ages. Christians did not believe in unicorns. Premodern medical diagnosis did not merely appeal to supernatural causation. And the list could continue.

Instead, as Hutchings and Ungureanu explain over the course of their nine chapters, Christianity—and especially medieval Christianity—was hyper-rational and actively engaged in scientific thought. So, despite the continued influence of Draper and White since the nineteenth century, Hutchings and Ungureanu successfully demonstrate many errors with the historiographical tradition of the warfare thesis. In fact, as the authors argue, there were ways in which science borrowed from theology. This is most noticeable in the utilization of theology to explain science in the period known as the Scientific Revolution, which the authors address in chapter eight, "Old Dogma, New Tricks." Another helpful chapter pertains to the way the ideas of Draper and White resonated with others in the nineteenth century, thereby demonstrating how these two well-known intellectuals were not mere "lone voices." This latter point is a particularly helpful contribution to the topic's historiography, as this type of contextualization is oftentimes forgotten when considering Draper, White, and the warfare thesis.

It is for these reasons and others that many will find this book a helpful aid. The tone is conversational, and the citations are relegated to endnotes at the back of the book. The book also draws upon some of the best scholarship in the history of science from the past fifty years, such as the works of Edward Grant, Bernard Lightman, and the more recent contribution of Seb Faulk. One of the fortunate outcomes, then, is that the reader who reads between the lines will discover a masterful account of the ways in which the field of the history of science has effectively dismantled the warfare thesis, and in its wake established a robust understanding of the complex historical relationship between science and religion. The reader of the book will also be provided with an abbreviated version of one of the authors' works, James Ungureanu's *Science, Religion, and the Protestant Tradition* (2019), which is summarized in chapter seven, "Bridges Badly Built."

For all its merits, there is one point made occasionally that gives this reviewer pause. At times, the authors come close to ascribing a causal link between Christianity and science, such that Christianity was a dominant driver of scientific development. For instance, in chapter eight, wherein the authors address the positive influence of Christianity on science, they claim that "Christian dogma has actually played a major part—indeed, many have argued the major part—in establishing the foundations of the science that is so successful today" (p. 196). It shows up similarly at the end of chapter seven, with an even greater causal connection between Christianity and science. The point in chapter eight is substantiated by a reference to Noah Efron's chapter in *Galileo Goes to Jail*, titled "That Christianity Gave Birth to Modern Science." While Efron does ascribe an important role to Christianity in scientific development, he stops short of identifying it as *the* sole cause. Among the reasons for this, as Efron notes, is that it then becomes problematic to include the contributions of non-Christians to science. Yet, the reader *Of Popes & Unicorns* would not be informed regarding the potential error in over-attributing a causal connection between Christianity and science. In a book aiming to reframe the relationship between science and religion, one would have hoped that they would have nuanced this point, even if in the end they chose to argue for the importance of Christianity on scientific development.

This issue aside, the book is an important contribution to the study of the warfare thesis. Readers of this journal are perhaps aware of previous books on the topic, the most prominent one being *Galileo Goes to Jail* (2009). Those that are familiar with that book will find a certain amount of overlap in this one, though not complete synonymity. One clear merit is that this book is a comprehensive story, and not discrete chapters. As a result, its content will likely be utilized in many different contexts and read for many years to come.

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MAGIC, SCIENCE, AND RELIGION IN EARLY MODERN EUROPE by Mark A. Waddell. Cambridge, UK: Cambridge University Press, 2021. x + 220 pages, including an annotated bibliography and index. Paperback; $25.99. ISBN: 9781108441650.

For decades, it has been commonplace among historians of science to recognize the essential interconnections between Christianity and the early origins of the natural sciences, even if some non-historians continue to struggle to relinquish the more titillating revival of a conflict between them. The reality is that the social and intellectual history of theology and natural philosophy have vast overlapping boundaries. The history of the modern natural sciences is no less continuous with the ideas and practices of magic, alchemy, and astrology. While Enlightenment sensibilities chafe at the notion, historical research, much in the same vein as studies in "Science and Religion," is incontestable. Mark A. Waddell's brief introduction to the subject quickly brings the reader into this consensus without sacrificing the nuance needed to avoid oversimplification.

The strongest chapters are in the first half of the book, where Waddell introduces the Renaissance interest in Hermetic philosophy (chap. 1), then newly discovered among ancient texts (though not so ancient as they were first thought to be). The author proves to be a practiced communicator, able to simplify and condense a

range of philosophical principles. He also succeeds in connecting philosophies with the perennial social problems and questions of ordinary human experience. In this way, he is consistent with a long line of scholars writing on the subject, from Keith Thomas's, *Religion and the Decline of Magic* (1971) forward. The subject of witchcraft and demonology (chap. 2) is treated as the manifestation of social anxieties within European culture more generally.

The broadest principle of magic is covered in chapter 3, "Magic, Medicine, and the Microcosm," in which Waddell explains the overarching analogy between the greater universe out there and our mundane existence down here. This forms the basis for both astrology-based medicine (noting concordances between either herbs or organs with their astrological counterparts and using them to heal) or judicial astrology, which sought to understand the past and map the future by virtue of astrological motions. And Waddell presents this as a normal part of early-modern thinking among churchmen and commoners alike.

The second half of the book covers topics which may be more easily recognized as parts of modern natural science: Galileo, Copernicus, Boyle, and Newton. Chapter 4, "A New Cosmos," uses a most creative and pedagogically sensitive introduction to the radical proposal of a world system in which the earth is not motionless and at the center of the universe. Waddell uses the demotion of Pluto from planetary status in 2006 and the subsequent public backlash, and asks the reader to imagine, *a fortiori*, how the public might react to an even greater disruption of received astronomical dogma, however empirically informed. Waddell returns again in chapter 5, "Looking for God in the Cosmic Machine," to ancient philosophy, showing how Epicurean atomism presented an old philosophical problem anew in the philosophies of René Descartes and Pierre Gassendi, focusing on the question of the nature of the soul. Here the continuity of ancient and new philosophies is maintained, illustrating the ongoing development and connected history between modern natural science, magic, and religion.

That continuity might have been better represented with more emphasis on the philosophy of Aristotle and scholasticism. While Aristotle's philosophy is discussed in several places throughout the book, such as in the discussion above on the soul, a dedicated chapter would have been appropriate given the dominance of Aristotle in Western intellectual culture from the end of the thirteenth century through the end of the seventeenth. This weakness of the book was evident in chapter 6 in the section on Francis Bacon and the inductive method. Waddell says,

> Bacon founded his ideas about experience and experiment on what is known as *inductive reasoning*, or *induction* … In choosing to focus on singular observations, Bacon was of course doing exactly what Aristotle taught his students *not* to do. (p. 166)

Aristotle never gave such instruction. In fact, Aristotle describes induction in his *Posterior Analytics, Book I*, in the first sentence:

> All teaching and learning of an intellectual kind proceed from pre-existent knowledge … Similarly with arguments, both deductive and inductive: they effect their teaching through what we already know, the former assuming items which we are presumed to grasp, the latter proving something universal by way of the fact that the particular cases are plain. (Barnes translation, 1975)

Waddell misses that Bacon's emphasis on induction was not novel except in emphasis. The new science was an extension of old principles newly revived.

This introduction closes with a coda, extending briefly into the Enlightenment. This section is handled a little too quickly, but well enough to present some of the subtleties necessary to link it to its past. Not only does he present how Enlightenment intellectuals were embarrassed by Newton's alchemical adventures, but how the mechanical forces of modern science themselves still betray underlying occult qualities that formerly traveled under other names.

The author often used the word "problematic" (over twenty times) throughout the book: for example, in the sentence, "It is important to note that, however problematic the idea of a mechanical universe might have been, it did not disappear." The author uses the word so often, it is unclear if he merely means something less specific, like "challenging," as in "difficult to absorb" in one's concepts of the natural world, or more narrowly as something that violates social and political norms. Since Waddell in other places in the book seeks to contextualize these events of four hundred years ago within a modern idiom, it is at least plausible that he wishes us to connect the intensity of the social dramas of today with those past events. If so, an explicit recognition of that would have been helpful to the reader.

This book is suitable for an undergraduate course in the history of science, especially if flanked by primary source readings under the guidance of the instructor. A person with no background in the subject would also find this an accessible entry point into the subject, from which they could move on to more detailed studies, such as those noted in the bibliography.

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Neuroscience

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THE SOUL OF DESIRE: Discovering the Neuroscience of Longing, Beauty, and Community by Curt Thompson. Downers Grove, IL: InterVarsity Press, 2021. 238 pages. Hardcover; $27.00. ISBN: 1514002108.

The Soul of Desire sparks the reader's curiosity with the title. Often we relate desire to things we want but view as shameful or dysfunctional in life, such as sex, money and power. Although briefly addressing those things, this book takes the reader to a deeper level of understanding and applying God's definition of desire. Thompson uses art and personal narratives with the integration of theology, psychology, psychiatry and interpersonal neurobiology to help the reader see God's intent for beauty out of brokenness.

The first section of the book outlines the concept of desire. Thompson defines desires as what we want and long for. It is primal for humans to desire although we often don't understand why. It is innate but also must be cultivated and pruned. It is shaped by the practices and habits we develop: the expressions of our intention. Often our desires have less to do with what God longs for us to desire, himself, and more to do with being able to compete in the world—to be adequate and acceptable in the eyes of others (p. 13). He goes on to emphasize Jesus's interest in our desires. Jesus asks us to name our desires in John 1:38, "What do you want?" He argues that, often, we do not name our desires because we fear they may fall outside of the boundary of what God or others see as acceptable. But in not naming our desires, we become bored and depressed (p. 191). We are not living to our full potential.

God's intent is for beauty out of brokenness which we are able to see only when we allow ourselves to be vulnerable. How the brain processes interactions is based on past experiences, which often include trauma and shame. In Thompson's first book, *The Soul of Shame*, he unpacks this concept of shame and how it affects every aspect of our personal and vocational endeavors. It seeks to destroy our identity in Christ. Within this second book, he goes on to elaborate how beauty begins and ends with God, our relationship with God, and with each other. Our primal desire is not only to be known, but also to be curators and creators of beauty (p. 33). He emphasizes that in order to do this, we must learn to think of our story in a different way. God does not point out our sin merely in order to forgive us so we will go to heaven, nor does he identify our trauma and shame in order to heal them simply that we might feel better about ourselves. Instead,

> he is transforming us—creating us anew—to recommission us to do the work of new creation along with him. In this sense, God sees us not as problems to be solved or broken objects to be repaired but as beauty on the way to being formed. Sin, then, is what keeps us in a posture of resisting God's desire for creating beauty in, with, and through us. (p. 45)

Throughout a large portion of the book, Thompson is laying out how to move from trauma and shame to a new creation, by means of interpersonal neurobiology. This becomes a lived experience for participants within confessional communities. These communities are designed to enhance integration of the mind's nine domains of functional activity.

> This leads to the development of earned secure attachment, primarily through providing the opportunity for participants to be seen, soothed, safe, and secure and bolsters the social engagement system while enabling participants to widen their windows of tolerance, which prevents them from moving into stages of hyper- or hypo-arousal. These processes hinge on participation in a setting where the deep desire to be known is met. (p. 40)

In order to help the reader visualize how these communities work, he intertwines stories from various participants to demonstrate the process. The goal for each participant, in telling their story, is to name their desires and griefs and do the work of lament as a means of creating beauty in order to reach sanctification (p. 97). In order to go through these stages, participants must be willing to dwell on, to spend time with, and to contemplate these questions: "Where am I?" in reference to the mind, thoughts, and emotions; and "With whom am I living?" in reference to who else consumes our thoughts.

Thompson does an outstanding job of helping the reader process each phase that participants in the communities must go through (imagine, dwell, gaze and inquire) in order to attain their desires, all while connecting each phase back to the process of sanctification in order to move closer to the new creation. He uses the Easter story to help the reader understand. Without Easter there is no story, "… to see how beauty is coming to find you, calling to you in your grieving, traumatized, disintegrated life in order to transform the crucifixion of your soul into the beauty of resurrection" (p. 90).

The book ends with descriptive ways in which groups of people can use this process to start to move toward implementation of a confessional community within various settings. Although this was helpful, it left the reader wanting to know more about the process, to understand how to apply the process more effectively.

I would recommend this book to anyone who wants to build a sense of community within a group of people. Simply understanding the process of how humans develop a sense of belonging that can end in beauty strengthens the human and spiritual connection.

Overall, the book does an excellent job of identifying the true desires of the human soul. Thompson effectively connects the dots between science and faith through the lens of beauty and relationship. He incorporates the mind of a biblical scholar, the wisdom of a psychiatrist and researcher, and the heart of a pastor through biblical narratives, stories of the human experience and neuroscience. He encourages us; even in a broken world, God can work through authentic and vulnerable community to create beauty from places of trauma, and he can make all things new.

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Ψ Philosophy

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DIVINE ACTION AND EMERGENCE: An Alternative to Panentheism by Mariusz Tabaczek. Notre Dame, IN: University of Notre Dame Press, 2021. xviii + 346 pages. Hardcover; $75.00. ISBN: 9780268108731.

In his classic *History of Western Philosophy,* Bertrand Russell refers to the Greek atomists, with their view of reality as consisting of atoms in a void, as a "point of view … remarkably like that of modern science …" Russell's reductionistic characterization of natural science was already showing its age when the book was published in 1946. And in the years since, those words have only become more dated with the rise of various models of emergence which offer endlessly novel ways to understand the ontological richness of nature.

While ontological emergence offers rich new ways of conceiving nature, it also brings novel challenges. Consider, for example, the problem of agent causation. Many Christian theologians throughout history have appealed to a substance dualist model of the self, but these models have generally fallen out of favor, not least because they appear to violate the principle of interdependence and the metaphysical inclusivity of ontological levels (p. 44). While ontological emergence proposes that mental states supervene on physical states, it becomes very difficult to conceive how, on this model, the mental can bring about changes in the physical. The dilemma, in short, appears to be between epiphenomenalism (i.e., mental events do not cause anything) and causal overdetermination (i.e., both prior brain states and mental intentions bring about subsequent brain states) (cf. pp. 36–37).

This strange new world of ontological emergence not only poses a challenge to, but also presents an opportunity in several fields. This includes theology where it has spurred the exploration of various novel models of divine action. Arguably, the most significant trend of note in this regard has been the rise of panentheistic models of the God/world relation. While panentheism goes back centuries, it has firmly entered the mainstream with the complex models proposed by scholars such as Arthur Peacocke and Philip Clayton.

While panentheistic models of the emergent world offer new avenues of theological exploration, they also offer a range of challenges. For example, by construing God as one agent among others, they face the problem of a causal joint at which divine action (e.g., as energy or pure information) providentially enters into and thereby guides natural processes. One way to avoid that problem is by construing ontological gaps and God's action as occurring everywhere in space and time (p. 150). On the downside, this account threatens to lose the distinctiveness of particular instances of divine action. Other challenges to panentheism include the basic question of meaning: that is, what does it even mean to say God is in the world or that the world is God's body?

Given the difficulties with panentheistic accounts of divine action in a creation rich with ontological emergence, could there by another way of conceiving of divine action? At this point, I am reminded of the famous G. K. Chesterton quote: "The Christian ideal has not been tried and found wanting. It has been found difficult; and left untried." Might it be that this is true of classical theism as well? Might classical theism in general, and Thomism in particular, offer rich resources to explore the complexity of divine action in a nature rich with ontological emergence?

Mariusz Tabaczek believes so, and in *Divine Action and Emergence* he develops a penetrating critique of the panentheistic turn while defending a return to the resources of classical theism, and specifically the work of Aquinas. Tabaczek develops his model, which seeks to repristinate an Aristotelian and Thomistic account of causation, in dialogue with Terrence Deacon's exploration of emergence, through the category of absence and creative potential. Tabaczek puts his own spin on that intriguing (if rather obscure) concept with an exploration of Aquinas's Aristotelian four-fold model of causation.

To begin with, Tabaczek argues that God should be viewed as the efficient cause of all creaturely being. However, God does not act on the same ontological plane as creatures but rather as a principal cause that empowers creatures to act as instrumental causes in accord with their created dispositions. This double

causation framework allows us to understand God's action as meticulous concurrence while also avoiding the danger of occasionalism by preserving the distinctiveness of created causal powers or dispositions. God also acts as formal cause through the granting of *esse* in accord with the exemplars of being in the divine mind. As God actualizes creatures they participate in the divine ideas. Finally, God creates and sustains creaturely being as final cause in accord with the *telos* of every being. Collectively, these spheres of divine action provide a framework to understand God acting meticulously at all levels of nature while maintaining the distinctiveness of created being, respecting levels of ontological emergence, and avoiding the challenges posed by localized discrete action at a specific causal joint.

Divine Action and Emergence is packed with insights and rewarding features, including a fascinating and detailed overview of the many recent models of emergence (chap. 1) and a clear and concise history of major panentheistic theologies down to the present. Time and again, I appreciated Tabaczek's ability to make multiple subtly nuanced distinctions as with his many possible interpretations of the seemingly innocuous preposition "en" in panentheism.

Not surprisingly, Tabaczek's model invites its own questions. While he addresses the problem of evil by appealing to an Augustinian concept of privation, I am not persuaded that this abstract notion is a very effective theodicy. It seems to me the problem of evil is not so much about an abstract absence of being so much as the undeniably real and all-too-concrete suffering of individual sentient beings, and that problem very much remains even if overlaid with an Augustianian ontology of evil.

Among the other challenges faced by this kind of Thomistic model of the God/world relation is the implication that God has no real relation with the world (p. 163), such that all changes in the world merely constitute Cambridge changes in God (i.e., changes not involving God's intrinsic nature). Tabaczek responds by citing Michael Dodds who claims that, in virtue of lacking a real relation with creation, God is "infinitely closer" (p. 165) to created being. This reminds me of the defender of impassibility who says God is not unloving but rather is already fully actualized in his being. Nevertheless, I suspect many critics will find this an unsatisfactory rejoinder and thus will still look for a "two-way relation" between God and the world. It is also worth noting that panentheism is certainly not the only way to establish this two-way relation.

Divine Action and Emergence provides a very detailed summary of the contemporary debate on emergence and panentheism while offering a bold new proposal that promises to reinvigorate Aristotelian causation for our day. The book has many virtues including the aforementioned overview of the field of emergence theory and concise history of panentheistic theological models. By reconciling classical theism to contemporary work in emergence (most notably, that of Deacon), Tabaczek lands a serious blow against the popular notion that panentheism offers superior resources for conceiving divine action within an emergent framework. Along the way, he also retains the virtues of classical theism, including a robust commitment to divine aseity and transcendence, *creatio ex nihilo*, and meticulous providence alongside created autonomy and human free will.

This is a rich and dense book and is a must-have for scholars in the field as well as university libraries. While Tabaczek expresses the hope that the book will also find a readership among the clergy, I suspect the high level of technical discussion will limit its broader appeal.

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GOD, HUMAN, ANIMAL, MACHINE: Technology, Metaphor, and the Search for Meaning by Meghan O'Gieblyn. New York: Doubleday, 2021. 304 pages. Hardcover; $28.00. ISBN: 9780385543828.

Meghan O'Gieblyn's *God, Human, Animal, Machine* is the most honest, insightful, and therefore challenging book of its kind I have ever read. Part intellectual memoir and part philosophy, it walks us through O'Gieblyn's journey away from the Christian faith of her youth toward seeing herself "more or less as a machine" (p. 7). God, she has become convinced, is a projection of the human imagination, a product of our solipsism. "For centuries we said we were made in God's image, when in truth we made him in ours" (p. 12).

This is such a common late modern narrative of disenchantment that the reader expects the usual suspects to follow. Namely, vitriol against the ignorance of theologians, and a solid articulation of the merits of scientific naturalism. But that is not what we get here. What we get is the kind of intellectual honesty that is willing to admit that if humans are inherently meaning-making creatures, then all of us could be getting it wrong.

O'Gieblyn maps her own disenchantment narrative onto that of the modern western world. Descartes couldn't be sure of anything but his being a thinking thing; Kant couldn't be sure that those thoughts had anything to do with the world as it actually is. Once you go through this door, the only honest position is that every human belief about ultimate reality is based on faith in something. She makes this point brilliantly through David

Chalmers, who endeavored to explain the idea (said of philosophers) that "one starts as a materialist, then one becomes a dualist, then a panpsychist, and one ends up as an idealist" (p. 180). Chalmers knows that each of these perspectives necessarily entails accepting different metaphorical lenses, none of which can be definitively proven by science or philosophy.

O'Gieblyn thus finds Bernardo Kastrup's "shortcut through this trajectory" particularly fascinating. For Kastrup, consciousness is all that exists, and the "entire observable world is patterns of excitation" of a "universal mind" that is the cosmos (p. 185). "By the time you seriously consider all the options and their limitations," O'Gieblyn writes, "the idea of God begins to seem just as crazy as anything else" (p. 185). She knows how this sounds, and immediately wonders if she's predisposed to this position because of her previous faith and her desire for meaning. And she is correct: there can be no way out for the honest skeptic. "It's not as though I never experienced God's presence or guidance as a Christian; it was that I could not, as so many of my friends and classmates managed to do, rule out the possibility that those signs and assurances were merely narratives I was constructing" (pp. 187–88).

I found this refreshing precisely because O'Gieblyn knows it cuts both ways. If Christians and materialists could admit to sharing this limitation, we might have a new starting point for genuine, and possibly life-changing, conversations. O'Gieblyn has done her scientific and philosophical homework, and she's found the stumbling stone for everyone: consciousness. For despite the arrogance of titles like Daniel Dennett's *Consciousness Explained*, scientists and philosophers familiar with quantum physics know that there is a lot up for debate here. The hard problem of consciousness is not a God-of-the-gaps thing, where we tack the "mystery" label on something we can't explain and then return to happy-clappy worship. It's a whole world of weirdness, and God could be behind it all. Or not.

O'Gieblyn's intellectual honesty leads her to be able to pinpoint exactly what it is she is rejecting when she rejects the Christian God. She identifies first with Job, and then with Ivan in *The Brothers Karamozov*. In a pivotal conversation between Ivan and Alyosha, Ivan can't stomach the fact that God's work in this world would require innocent children to suffer. He says, "I would rather remain with my unavenged suffering and unsatisfied indignation, *even if I were wrong*." While O'Gieblyn's Moody Bible Institute classmates saw Alyosha's response of loving faith the point of the passage, "what the novel had made clear to me was that I deeply admired Ivan in his rebellion, just as I had admired Job in his" (p. 235). She was able to reconsider her apostasy as an act of courage. She is not rejecting God, but a "system of human thought" (p. 236).

This frankness is reason enough for me to wish I could have a regular coffee date with O'Gieblyn. But I'm barely scratching the surface of this wide-ranging, insightful text that does an especially superb job of analyzing the ideology of digital culture. All cultural metaphors create meaning and then disappear from view as metaphor. The digital age's primary metaphors (brain as computer; mind as nodes on a network) have left us with a particular view of being, "which might be described as an ontology of vacancy—a great emptying-out of qualities, content, and meaning. This ontology feeds into its epistemology, which holds that knowledge lies not in concepts themselves but in the relationships that constitute them, which can be discovered by artificial networks that lack any true knowledge of what they are uncovering" (p. 245). In short, in the twenty-first century, individuals don't lead out of good character with altruistic motives. Memes gain influence not by being good ideas, but by being irresistible clickbait. Although O'Gieblyn describes this ideology with incredible journalistic restraint, there can be no doubt. This is our epistemological crisis, and it is not going anywhere anytime soon.

Carefully researched and beautifully written, *God, Human, Animal, Machine* provides an excellent starting point for meaningful discussion between atheists and believers. It is a valuable resource for anyone interested in the relationships between science, technology, and religion.

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TECHNOLOGY

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A CHRISTIAN FIELD GUIDE TO TECHNOLOGY FOR ENGINEERS AND DESIGNERS by Ethan J. Brue, Derek C. Schuurman, and Steven H. VanderLeest. Downers Grove, IL: IVP Academic, 2022. 226 pages including discussion questions, endnotes, credits, and indices. Paperback; $28.00. ISBN: 9781514001004.

Finally! The long-awaited update to *Responsible Technology: A Christian Perspective* (Stephen V. Monsma, ed., Eerdmans, 1986) is here, and this new book is well worth the wait. Framed as a practical field guide for engineers, it is also adept at illuminating some of the philosophical issues that swirl around the interface of technology and Christian faith. Hearty pats-on-the-back to Ethan Brue, Derek Schuurman, and Steven VanderLeest for undertaking and completing this grand project in such fine fashion.

It begins with an inspiring discussion of the connections between humankind's technological hopes and dreams and our ultimate hope in our Maker. Historical accounts and personal stories by each author will surely be an encouragement to young people who are curious about technology from a Christian perspective. Indeed, this book would make a good text for a university-level "Introduction to Engineering" course. The book continues with an insightful survey of how technology relates to the biblical story. This includes a discussion of humanity's first great commission to steward the earth, as well as the influence of fall, redemption, and re-creation on our engineering enterprises.

It gets even more interesting (and philosophical) as the authors next address the popular false narrative that all technology is inherently neutral. Several examples help to expose myths about the universal usefulness and neutrality of tools, the ends justifying the means, and forms of technological determinism. This is followed by a discussion of what constitutes responsible and discerning design, including technological mediation and unintended consequences. This naturally leads into the real "meat" of the book, which deals with design norms, or guiding principles that designers should seek to follow.

The authors extend the original list of norms in *Responsible Technology* to include categories of analytical, cultural, clarity, social, stewardship, harmony, justice, caring, and faithfulness. Common ethical frameworks are then presented that build on these design norms. This is excellent background knowledge that will greatly benefit engineering students, as well as practitioners. Although a Christian worldview pervades the entire book, it is explicitly addressed in "Modern Towers of Babel" (chapter 6) which explores the results of sin on engineering and resulting technologies. A helpful distinction between finiteness and fallenness illuminates this discussion.

The engineering of electric vehicles provides a fascinating example of how important historical context and past industry contribute to understanding in current designs. With this background, the design norms are then applied to envision the responsible development of a future electric vehicle. A chapter on technology and the future follows, with discussions of technological optimism, pessimism, and transhumanism. A biblical view of the future of technology concludes this section by framing it all in a Christian perspective. I imagine this section will be exciting for young engineers as they envision how God is calling them to use future technologies to influence the world for good and not for ill..

However, I found the second-to-last chapter (on technology for evangelism and missions) to be the most interesting. Here we are reminded that technological work is a legitimate Christian calling, since "Our worship does not start and stop with the formal service in a church building … worship can and should be an ever-present mindset and continuous act" (p. 175). And training as a technologist not only enables one to use technology in serving others physically, but it also provides access to the technological community where one can have an even more profound influence. The authors emphasize that "While Christians from a wide variety of vocational backgrounds can serve as missionaries in developing countries, only those with a highly technical education can serve as missionaries to this corporate mission field. Technical expertise opens doors" (p. 168). Readers are encouraged to develop their own unique and creative ways to use technology to love their neighbor. But this is about as close as the authors get to discussing what may be an important calling for many Christian engineers, that of the evangelist/apologist. I would like to have seen more discussion on how the expertise of engineers enables them to answer questions on science and faith apparent disagreements, questions asked by both skeptics and believers. Engineers are uniquely qualified to serve as mediators and peacemakers in the science and faith conversation, and unfortunately, perhaps due to size constraints, this aspect was not mentioned in the book.

Finally, I hope that readers make it to the last chapter since I found it particularly meaningful. It consists of a series of emails between a young engineer and his former engineering professor and mentor at a Christian university. Although the letters are fictional, they raise many questions that often arise within the first years of an engineering career. And the good professor dispenses his wisdom with keen insight and grace. Overall, I found this book to be a much-needed addition to the conversation on technology and Christian faith. And I think it should be widely considered as required reading in the first year of engineering programs at Christian universities. The questions for reflection and discussion at the end of each chapter are very thoughtful and provide a helpful resource in this regard.

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DOI: https://doi.org/10.56315/PSCF3-23Crouch

THE LIFE WE'RE LOOKING FOR: Reclaiming Relationship in a Technological World by Andy Crouch. New York: Convergent Books, 2022. 226 pages, including notes. Hardcover; $25.00. ISBN: 9780593237342.

In *The Life We're Looking For*, subtitled *Reclaiming Relationship in a Technological World*, author Andy Crouch examines modern Western life given the ubiquity of and our dependence on technology. This is not a book about technology—you will not learn anything

new about the Internet, your cellphone, or AI. Instead, you will be asked to examine life in this modern age rife with loneliness, how we got here, and what we can do about it.

The book is divided into three sections: six chapters identifying the problems of the modern age, a one-chapter "intermission," and five chapters identifying solutions to the problems. The problems of this world can be summarized by the subtitles of the first six chapters: "The Loneliness of a Personalized World," "What We've Forgotten about Being a Person," "How We Trade Personhood for Effortless Power," "The Ancient Roots of Our Tech Obsession," "How Impersonal Power Rules Our World," and "Why the Next Tech Revolution Will Succeed—and Also Fail."

One of Crouch's major themes is that our modern conveniences promise us superpowers. This sounds like a good thing, but in reality it is not. Cars, trains, and planes allow us to move great distances quickly with little effort. Our cell phones give us the ability to translate languages, access vast amounts of information, and communicate almost instantaneously with people around the world. Even our household devices allow us to clean our house without any effort. How these devices work is, for most of us, indistinguishable from magic. Yet, having these abilities leaves us without the need for relationships, and without the need for long-term investment in a project or craft—such as learning a foreign language or learning to play an instrument. We lack the need (and ability?) to love with our full heart, soul, mind, and strength. We are allowed to skim across the surface of life instead of diving deep into it.

Another major theme of the book is Crouch's definition of Mammon. In Matthew 6:24, Jesus says, "You cannot serve both God and Mammon." Crouch expands Mammon from a concept to a being. Mammon is the demonic creature that rules the world. "… What [Mammon] wants, above all, is to separate power from relationship, abundance from dependence, and being from personhood" (p. 76). Mammon and money are closely related, for money makes possible "the ability to get things done, often by means of other persons, without the entanglements of friendship" (p. 72). Crouch then ties in technology: "What technology wants is really what Mammon wants: a world of context-free, responsibility-free, dependence-free power measured out in fungible, storable units of value" (p. 78).

In the "intermission" chapter, Crouch takes us to the table of Gaius, in Corinth, in the second century AD. Around the table are seated wealthy and powerful men, scribes, slaves, and women, and, notably, Paul the apostle. These people share a meal together as equals. They pray and sing together. This is radically counter-cultural. Their actions acknowledge that all people are recognized as persons—image bearers of God.

To solve the problems highlighted in the first part of the book, the author proposes that we need to influence the world, not impact it. "Impact" implies applying a great force for a short period of time. "Influence" implies relationship, patience, and a slower pace. We should seek to use and create technology as an instrument that enhances personhood, does not promise short-term, instant gratification, and elevates and dignifies personhood.

Crouch identifies the promises made by technology: (1) "Now you'll be able to …," and (2) "You'll no longer have to …" (p. 139). He encourages us to think carefully about what these promises are and how true they are. He then identifies the negative consequences of adopting a given technology: (3) "You'll no longer be able to …," and (4) "Now you'll have to …" He then illustrates these promises and consequences with music, available ubiquitously now due to smartphones and the internet, and listened to on earbuds or headphones: (1) Now you'll be able to listen to anything, anywhere. (2) You'll no longer have to listen to others' music in a shared space. (3) You'll no longer be able to make time to practice an instrument so that you can make your own music. (4) Now you'll have to keep upgrading your phone/device/provider so you can get all the best music (p. 140).

To address the epidemic of loneliness, Crouch proposes we should all live in "households". Households are not just families, which may live thousands of miles apart. Households are groups of people sharing life together in community—living, eating, "doing life" together. A household means knowing where each person is and how each person is feeling that day. Crouch goes further, suggesting that we should stop seeking the "blessed" life, which he renames the "charmed" life, free from suffering and burden. Instead, we should include in our communities the "unuseful" person—the person who cannot contribute as much to the financial support of the community, due to age, (dis)ability, or health. To do so will change our hearts from desiring a charmed life to desiring to be a blessing. Moreover, it will radically acknowledge the full personhood of these others.

Andy Crouch gives compelling evidence for what he sees is wrong with life in Western society today. The book is full of wise observations—I have highlighted a sentence or two, if not a full paragraph, on most pages. I found his advice for positively influencing our world to be compelling and practical. His "treatment plan" for addressing loneliness was the most challenging for me. As an introvert, I like and need alone time. I'm not sure

I could live under one roof with many other unrelated people. Still, the idea is noble, if perhaps impractical for many people.

I highly recommend this book. It is an easy read, and, more importantly, it will make you think.

Reviewed by Victor Norman, Associate Professor of Computer Science, Calvin University, Grand Rapids, MI 49546.

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GOD, TECHNOLOGY, AND THE CHRISTIAN LIFE by Tony Reinke. Wheaton, IL: Crossway, 2022. 320 pages. Paperback; $21.99. ISBN: 9781433578274.

The ASA has long opposed the myth that science and Christian faith are incompatible. Nevertheless, ASA members differ on all sorts of issues. With little consensus on biblical eschatology, the greatest differences may be on issues related to the future. If so, then Tony Reinke's *God, Technology, and the Christian Life* is sure to be thought provoking, for its focus is the ongoing explosion in scientific knowledge and its applications.

Reinke, a journalist and author of several books, is associated with John Piper and his Desiring God ministry. He adheres to Piper's Reformed theology and trademark "Christian hedonism," which holds that our chief end is to "glorify God *by* enjoying him forever." So Reinke is not only a Christian hedonist, but also a tech hedonist. Today's gadgets delight him, and he looks forward to more wonders in the future. Even so, Reinke's hopes are well placed; he is "optimistic—not optimistic in man, but in the God who governs every square inch of Silicon Valley" (p. 30), a statement that summarizes the entire book.

A concluding section explains the book's origins (pp. 303–4). To write an introduction for *12 Ways Your Phone Is Changing You*, published in 2017, Reinke found it necessary to "catalog" his "meta convictions about human innovation." He went on to develop his convictions, revise and extend his catalog, do more research, and present his findings to several audiences, both in person and online. Finally, he assembled his lectures to produce this text. Unfortunately, it seems that this process left serious style problems. Individual chapters have a stand-alone quality, to the point they seem disconnected from the rest. Chapter-end summaries belabor the book's main points. Overall, the book's repetitive style obscures its connecting logic.

So what does the book argue?

In the Reformed tradition, Reinke seeks to develop a "biblical theology of technology" (p. 30). He begins with God's sovereignty in creation, and continues with God raising up image-bearers to explore nature and invent tools. Finally, Reinke argues that God stands over those that "wield" technology, for both good or evil; even their worst acts (e.g., the crucifixion of Christ) are "hacked" by God to achieve our redemption, which was planned "before the foundation of the world." Technology is a feature of history, but it does not drive it. Instead, history always unfolds in accordance with the divine will.

The book is organized around nine people, nine primary Bible passages, and twelve common myths about technology (pp. 25–29). Some subjects are predictable (e.g., Babel), but others are not, giving some depth to Reinke's analysis. Six chapters broadly address key questions: "What Is Technology?," "What Is God's Relationship to Technology?," "Where Do Our Technologies Come From?," "What Can Technology Never Accomplish?," "When Do Our Technologies End?," and "How Should We Use Technology Today?" In Reinke's repetitive style, chapters conclude with numbered lists of "Takeaways" that summarize, and sometimes extend, main points.

So, does Reinke succeed? Is his "biblical theology of technology" sound? Depending on their theological presuppositions, readers will judge differently.

Reformed readers, like me, will appreciate Reinke's emphasis on God's sovereignty. In this view, nature testifies to God's existence and wonderful character, and so does technology, its wonders rooted in the divine attributes, and produced by image bearers that reflect them. Tech demonstrates God's creation of both nature and human innovators, and it plays important roles in the plan of redemption, all to the glory of God.

Readers from other traditions will differ to the extent they look to human agency to shape history and the future. Surely, mature Christians understand salvation is based in God's grace, but then what? Christians should live out their faith, but to what extent do their choices matter? Ultimately, are God's promises fulfilled by him alone, or are they realized somehow through human action, including work in science and technology? In Alfred North Whitehead's *process theology* or Philip Hefner's created *co-creator ideas*, humanity achieves, to some degree, what God has promised in the eschaton. Indeed, such thinking is common among self-identified *Christian transhumanists*.

In Reinke's Reformed view, such hopes distract from life's purpose, our chief end: the glorification of God. Instead, dreams of human self-sufficiency tend toward idolatry. God, jealous for his own glory, has placed that goal beyond our reach, and in our rebellion against God, its relentless pursuit only displays our depravity.

Yes, but even this view calls for boundaries. Where does our misguided quest for self-sufficiency end, and

where do warranted good works begin? Does not scripture authorize the development and use of technology to reduce suffering and to love our neighbors? To what extent can we delight in inventions without making them idols?

Unfortunately, Reinke does not answer these questions; quite the opposite. He criticizes Christians wrestling with such issues for using descriptive labels (e.g., scientism) because, in his view, they limit "thoughtful conversations on technology" (p. 29), yet he is unequivocal in opposing proclamation of a "Gospel of Technology" (pp. 163–73). But again, how should Christians find our limits under God's rule? This question seems less important to Reinke than simply believing God will make the most of whatever happens.

Yes, the final chapter highlights the necessity of wisdom in *using* technology, wisdom that is available from God alone. But does not God give insight to all people? May we reasonably view science and technology as evidence of common grace, but deny that common grace could affect how society organizes and operates? Reinke praises the Amish for making deliberate decisions regarding technology, suggesting that all Christians would do well to do the same, but what criteria should we choose?

Ultimately, Reinke leaves all the big questions to God. Confident in him, Christians should just do the best they can, and then be content with the results. They are, after all, ordained by God. Surely this is true to some extent, but this leaves Reinke's "biblical theology of technology" open to the classic criticism of Reformed thought: under its banner, Christians are not fully responsible for the results of their actions.

On this point, deep differences appear between Reinke and other Christian observers of technology development. For example, in *A Christian Field Guide to Technology for Engineers and Designers*, Ethan J. Brue, Derek C. Schuurman, and Steven H. VanderLeest argue that, compared with others, Christian innovators bear a *greater* responsibility than others. Informed by biblical ethics and wisdom, they must go beyond minimal success measures. Engineering leadership means faithful conformance to rules, and then some; supererogation is the requirement. But in the end, the message is the same: follow the rules—expressed in either policy or scripture—and the results will surely be good. Well, history reveals limits to that idea. And again, judgement is required. We must not only recognize that moral choices shape technology and its use, but also avoid an empty and uninformed tech moralism.

We might want clear lines separating good from evil in technology, but neither Reinke nor other Christian authors can supply them. But to be fair, to what extent do people note and observe the clear lines God gave us in the Ten Commandments, the Sermon on the Mount, and many other passages? Until we leave this troubled world, clearly, we must walk by faith, not sight. So, as we walk through our technoscience-saturated world, Reinke and other Christians with biblical views of technology serve the church well. Surely, many ASA members, from diverse theological traditions, will find *God, Technology, and the Christian Life* interesting—either stimulating or frustrating—as well as contributing to further explorations of technology in the light of scripture.

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THEOLOGY

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THE END OF THE LAW? Law, Theology, and Neuroscience by David W. Opderbeck. Eugene, OR: Cascade, 2021. 260 pages. Paperback; $31.00. ISBN: 9781498223898.

"It's not you but your brain." As this powerful meme has begun to characterise our generation, we encounter children under neurological treatment for their behavioral/mental deficits and seniors losing their self-identity due to neurological degeneration. It is indeed evident that our mental experiences are bound to our brain states—yet are we really nothing else than our brain? Many intellectuals of our day argue so—our psyche is an epiphenomenon of our brain state, and so we have no free will.

Recent advances in neuroscience, especially with non-invasive neuroimaging techniques enabling scientists to "read out" one's decision ahead of a person being consciously aware of their own decision, have underpinned a new movement called neurolaw. According to neurolawyers, humans are no longer legally or morally accountable for their behaviors as science leaves no room for the existence of free will; consequently, law should be re-oriented from retribution to treatment of criminals. Indeed, neurolaw seeks "to explain and reform the legal system from the ground up based on neuroscience" (p. 2). Despite, or because of, its radicality, the neurolaw movement can be an attractive alternate to the legal tradition of Western civilization, which is rapidly losing its Greco-Roman/Christian foundations in law and ethics. It is also in line with the trend that our contemporaries increasingly seek justice through facts/science and empathy instead of transcendent values and rationality.

Although neurolawyers optimistically hope that this shift will lead our world from conflicts in subjective

values/beliefs to facts of science, and from moral retribution to humane treatment of criminals, in this book Seton Hall University Law School Professor David Opderbeck carefully considers their optimism legally, philosophically, and theologically—and concludes that, with no place for transcendence, their optimism is misplaced. Neurolaw's reductionism loses not only the place of personal responsibility in law and jurisprudence, but loses a rich and complex understanding of human nature and relationality. Opderbeck argues that theology can defend the transcendence of law and human morality, without losing its integrity to science, by understanding the laws of nature as empowering nature to fulfill its *telos*—its divine purpose. This move is key to a unified epistemological view on science and law, such that human-made laws empower humans with freedom and personhood—physically, legally, and morally. Consequently, the author reframes positive law (i.e., human-made law) as calling humans to the divine law of love.

In the first three chapters, Opderbeck illustrates how Western law made the historical shift from its foundational transcendent values, through legal positivism, to neurolaw. Contrary to the contemporary jurisprudential trend, the four rudiments of Western law, i.e., Ancient Greek, Roman, Hebrew, and Christian jurisprudence, commonly state that positive law has transcendent sources and is preceded by the ideal of law or universal moral principles (chap. 1). In contrast, today's Anglo-American legal scholarship, dominated by legal positivism and instrumentalism, removes transcendent grounds for law, replacing it with a hope that economics and science can guide the law by providing a measurement of "good" and predictions of its outcome (chap. 3). The current reductionist trends in neuroscience paint this picture with a greater hope by revealing detailed biological determinants of human behavior.

In chapters 4 and 5, Opderbeck provides a methodological basis for his analysis in the later chapters. He favors critical realism and *fides et ratio* approaches as they permit separate and yet complementary research in the two domains. He then demonstrates how together these can help to uncover the meaning of the law from the facts of paleoanthropology and sociobiology. Whereas sociobiologists such as David S. Wilson suggest that the contingent evolution of social orders in animals indicates that law is a construct with no transcendence, Opderbeck highlights the emergence of unique human cognitive abilities such as abstraction, language, and writing, which he argues enable the law to transcend the social orders observed in other species.

After showing that the facts of paleoanthropology and sociobiology can be interpreted differently from a materialist view, Opderbeck continues his philosophical criticism of the reductionism/materialism on which neurolaw is based (chap. 6). He points out that the fields of neuroscience and the philosophy of mind retain positivist assumptions. The author then identifies three problems in materialistic/reductionistic/positivist views of the law. First, reductionism cannot provide a coherent epistemological ground to make a truth statement since reason and consciousness are only illusory. Second, neurolaw proposes social engineering toward achieving behavioral normalcy in the population, but this leads to obscurity in value judgement—and, more seriously, to totalitarianism. Finally, materialism easily leads to nihilism.

Opderbeck's theological vision (and counterproposal to neurolaw) is uncovered in the last three chapters of the book. In chapter 7, he discusses the ontology of the human mind and free will. For this, he rejects the nonreductive physicalism of theologians such as Nancey Murphy and Robert van Gulick. He then finds more promising a neo-Aristotelian, teleological understanding of natural law as "powers and capacities" that emerge within nature (p. 173). These, rather than deterministic neurobiological rules, can be key to theological synthesis of science and law. To him, this view not only provides a plausible causal or explanatory framework but requires complementary room for transcendence: God's trinitarian, perichoretic transcendental love provides the *telos* for creation, and so the purpose of positive (human-made) law is to fulfill this transcendental *telos* through the "powers and capacities" of natural law

Opderbeck then assigns his last chapter to an applied problem, namely the problem of violence in the enforcement of law. Indeed, this issue appears to be one of the most important motivations for neurolawyers: neuroscience seeks to transform the means of law enforcement from retributive violence to more humane, neurological treatment. Nonetheless, through discussions of Pascal, Derrida, and Agamben, the author demonstrates that the law cannot bring justice without violent enforcement. Therefore, by forgoing divine transcendence it is impossible for neurolaw to overcome the problem of the violence of law. Opderbeck thereby puts forward the necessity of Christian teleology for an ultimate hope. Law is not a matter of deterministic rules but of love and life, and law is not of enforcement but empowering. What makes humans is not our capacity to make free choices but to be free to love and live; this is our *telos*.

The End of the Law? is a scholarly interdisciplinary book, which crosses over the philosophies of law, mind, science, and theology in order to challenge or re-orient the current dominance of legal/scientific positivism, reductionism, and physicalism among intellectual groups.

This dense book suits those who are already exposed to philosophical analysis on some of these topics (or, for readers unfamiliar with some of this terrain, but willing to do some background reading). Despite the degree to which it engages questions in philosophy, the book ultimately seeks to re-orient the law around Trinitarian theology. As this will limit its plausibility in public legal spheres, I do wonder if the philosophical argument could have been further developed for those who do not hold to Trinitarian theology (or any theology).

As a neuroscientist I would add one further note. There is little interest within neuroscience today in the problem of free will. In fact, students are discouraged from studying the question, as it is considered an unsuitable subject for scientific investigation. Most of us stay "scientifically agnostic," although individual scientists have their own philosophies or perspectives. Given that neuroscience is still restricted to a deterministic regime, free will can only be falsifiable but not verifiable, because it is widely considered beyond the laws of nature. It is, therefore, not surprising that one finds only evidence against free will, which comes from the epistemological constraints of the discipline of neuroscience today. I strongly suggest that proponents of neurolaw scrutinize at what point neuroscience reaches its methodological limits before assuming a particular ontological interpretation of experimental results to be "neuroscientific" or even unfalsifiable. The neurolaw program appears to be built without adequate recognition of these interpretive limits within neuroscience, no doubt due to its positivist assumptions. Overall, in Opderbeck's book readers will encounter rich and complex discussions across different fields integrating law, science, and theology. Although Opderbeck writes from a Roman Catholic perspective, this book does not feel like an in-house discussion—his foundational arguments are rooted in classical Trinitarian metaphysics and Protestants willing to work through Opderbeck's conceptually dense discussions will find much of value in this work.

Reviewed by Kuwook Cha, postdoctoral fellow in the Department of Physiology, McGill University, Montreal, QC H3A 0G4.

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THE INTEGRATION OF PSYCHOLOGY & CHRISTIANITY: A Domain-Based Approach by William L. Hathaway and Mark A. Yarhouse. Downers Grove, IL: InterVarsity Press Academic, 2021. 199 pages. ISBN: 9780830841837.

Reading *The Integration of Psychology and Christianity* brought to mind the lively discussions about integration that I had with my fellow undergraduates at Gordon College some twenty years ago. We were hampered in reaching any agreement by the fact that our assigned text, *Psychology and Christianity: Four Views*,[1] presented four authors who each defined integration in their own idiosyncratic way, which then resulted in us students talking past each other.

If only we'd had this book! Hathaway and Yarhouse resolve these confusions by offering a "domain-based approach." Rather than advocating for a particular integration approach, as has been common in integration scholarship, Hathaway and Yarhouse outline the multiplicity of ways in which the Christian psychologist might choose to integrate faith and psychology. This approach is one I found immediately useful, given my position as chair of psychology at a small Christian liberal arts college where I frequently mentor junior colleagues with less experience in Christian higher education as they learn to integrate faith into their teaching. Hathaway and Yarhouse's categories include the following: worldview integration, theoretical integration, applied integration, role integration, and personal integration. These categories not only offer a shared vocabulary for integration conversations, but they can serve as an inventory of one's comfort level in different types of integration (one may be quite comfortable doing personal integration while finding theoretical integration challenging, for example). Overall, the book is excellent as a catalyst for personal reflection and growth for the Christian psychologist, whether they be researcher, professor, or clinician.

A particular strength of the book is its emphasis on clinical and applied psychological work. The most original contributions are the chapters on applied integration and role integration. The former adapts a secular model for a Christian population or develops Christian interventions from Christian thought and practice while the later describes living out the role expectations of a particular vocation (e.g., counselor) in a way that is consistent with Christian identity. These chapters have many examples from Yarhouse and Hathaway's own experience in navigating these areas. Their clear articulation of the professional duties of the Christian who joins the counseling guild, for example, was extremely useful. I found myself grateful to have their take on role integration to offer to my aspiring therapist students, who often find themselves torn between personal conviction and professional obligations. Yarhouse and Hathaway offer a well-argued Christian perspective that emphasizes the priority of those professional obligations.

A few criticisms. I mentioned that this book reminded me of my integration discussions in the early 2000s. While the integration resources are helpfully updated and the whole book is very well resourced, I found that the core approach to integration had remained largely unchanged. That is to say, this is very much a book

written by two fairly conservative white American evangelical men. While the authors are moderates in evangelical terms, Yarhouse's scholarship (in sexual and gender identity) brings him into American culture-wars territory. It is not surprising, then, that they would see the challenges of Christian psychologists to be primarily in dealing with an often-antagonistic secular psychology. To be clear, far from advocating a hostile approach to secular psychology in return, they model a subtle Christian attempt to influence psychology policies to be more compatible with Christian values—and indeed their personal examples of successfully doing this are laudably sensible.

However, the revelations of evangelical complicity during the Trump years and the current rise of American Christian nationalism have left me questioning whether the largely apolitical nature of my Christian training in psychology was sufficiently transformational. I find myself yearning for a post-Trump integration analysis, an approach that grapples with the harms of evangelicals' quest for power. Or to put it another way, I question the idea, as sometimes implied by the authors, that the primary challenge Christians working in psychology face is the problem of too little cultural power.

The book's most obvious limitations in this vein are in the worldview integration chapter. Here we find the conservative nonprofit Heterodox Academy and its idea of "viewpoint diversity" uncritically embraced. The suggestion is that the conservative/Christian worldview should be considered a type of diversity akin to racial or gender diversity, given its minority status in liberal-dominated psychology. Given the very real challenges presented by racism and sexism, this framing seems at best tone deaf and at worst an encouragement to evangelicals to approach psychology with a persecution mindset. Also missing from this picture is the fact that the discipline often aligns itself with powerful interests and is therefore much less concerned with political beliefs per se than with power (to give just one example, the 2015 Hoffman Report documented how, during the Bush era, the American Psychological Association colluded with the US Department of Defence to change the APA ethics code to allow psychologists to participate in "enhanced interrogations" of terror suspects at Guantanamo Bay). Perhaps Christian integration efforts might involve an *Imago Dei*-informed attempt to challenge this status quo. My own graduate training in critical/feminist psychology prompted me to reflect on the harms that even well-meaning psychologists might perpetrate if they allow themselves to be used to enable the capitalist control of people. From Amazon warehouses to counseling practices, our neoliberal world offers many ways in which unwary Christian psychologists can contribute to the dehumanization of people. Counselors teach their clients to understand their mental struggles as caused by individual failings while ignoring the influence of systemic factors; this should be at least as much an ethical concern for Christian psychologists as the more typical hot-button trio of abortion, LGBTQ+, and euthanasia (Hathaway and Yarhouse tend to highlight these three in their examples).

Tellingly, in this book, the topic of social justice is relegated to the personal integration chapter as something that psychologists might choose to embrace as part of their individualistic spiritual development. Missing is the idea that justice or advocacy for the powerless might inform psychological theory from the get-go or even form a core part of the Christian worldview. In fact, the term "worldview" itself can be read as a sign of the static, inward-looking nature of the framing chosen here. Much as James Sire's books on the topic are classics, the fact remains that the term worldview is a distinctively evangelical Christian idea, out of touch with secular psychology. Further, the take on postmodernism that the worldview approach encourages verges on caricature. Although the authors of this book acknowledge some of these weaknesses, their choices in this chapter betray a lack of conversation with postmodern theorists in psychology, whose focus is not generally moral relativism but a critique of dominant power structures. Citing such scholars, many of whom make relevant critiques of psychology's philosophical blind spots, would have strengthened the worldview chapter.

One particularly clarifying move this book makes is to put integration typologies on a continuum with three major categories: assimilation, productive tension, and expanded horizons. The ideal integration work, they argue (riffing on Gadamer), results in an expanded horizon, where the insights of both sides are modified by fusion with the other. This idea is one that they might have taken further. Hathaway and Yarhouse are careful to articulate the privileged nature of scripture in such an encounter of horizons, but this seems to underestimate the cultural knowledge and assumptions that we import into scriptural interpretation. Surely the encounter of horizons is not pure divine revelation meeting pure psychological knowledge, but rather, the encounter is mediated by biased and finite human beings. The authors define worldview integration as "an attempt to reposition psychology within a cognitive frame that is coherently embedded within Christian thought and premised on Christian assumptions." I wish they had been more reflective about whose Christian thought and Christian assumptions they were presenting as normative. Given that this book is published by IVP Academic, this will likely not be a problem for their target audience, who probably share their assumptions. But I would expect a book that champions the expanded

horizon as the telos of integration to be more influenced by a diversity of Christian voices and a diversity of psychological approaches.

Perhaps this is more a complaint about psychology integration work as a whole, rather than this book in particular. Overall, I am very appreciative of this contribution, and simply hope that the foundation laid here can be used by readers to build integration efforts that are more self-reflective and outward-looking integration efforts than the book itself models. Hathaway and Yarhouse's main contributions in this book are (1) a comprehensive and sophisticated review of past integration work, (2) the helpful clarifying domain categories, and (3) innovations in the areas of applied integration and role integration, areas that previous integration work has neglected. For those hoping to get up to speed on integration work in psychology or hoping to grow in the sophistication of their integration efforts, this is a valuable resource and very much worth reading.

Note

[1]Eric L. Johnson and Stanton L. Jones, eds., *Psychology and Christianity: Four Views* (Downers Grove, IL: InterVarsity Press, 2000).

Reviewed by Elissa Rodkey, Associate Professor of Psychology, Crandall University, Moncton, NB E1C 9L7. ☼

Letters

Book Author Responds to Reviewers

Although I am gratified that *PSCF* should feature a review essay on my book *In Quest of the Historical Adam* (Sara M. Koenig and Cara M. Wall-Scheffler, "Discussions about Dispersals: Questions Rising from the Search for Historical Adam," *PSCF* 74, no. 4 [2022]: 242–45), I was disappointed to find that the reviewers misrepresented the basic positions and supporting arguments set forth in the book. It would be impossible to correct here every misunderstanding, so let me instead characterize positively and more accurately my proposed view. In the book I address two fundamental questions:

1. What are our biblical commitments concerning the historicity of Adam and Eve?
2. Are our biblical commitments compatible with the evidence of contemporary science concerning human origins?

In response to the first question, I present two arguments to show that we are biblically committed to a historical Adam and Eve: (1) The genealogies that order the primeval narratives of Genesis 1–11 and transform them into a primeval history meld seamlessly into the patriarchal narratives concerning Abraham and his descendants, who are indisputably regarded by the Pentateuchal author as historical persons, implying that their ancestors are likewise regarded as historical; (2) Although many of the New Testament references to Adam and Eve may be interpreted as references to merely literary figures of Genesis 2–3, Paul's treatment of Adam in Romans 5 implies that Adam was a historical figure, since no purely fictional character can have causal effects outside the world of the fiction, whereas Paul ascribes real world effects to Adam's fall.

Unfortunately, the reviewers conflate these two arguments on behalf of our commitment to a historical Adam with my reasons for thinking that the question of the historical Adam is theologically important (pp. 6–9, *In Quest of the Historical Adam*), leading to confusion on their part and, I fear, on the part of their readers. Their statement that "because we believe that God's love 'covers' everyone, we don't need a historical Eve (or Adam) to trust in the truthfulness of scripture" (p. 242) is a non sequitur and irrelevant to my arguments.

I was also surprised to learn that I "default to an enlightenment understanding of truth" (p. 243). As a professional philosopher, I have some knowledge of theories of truth and of the history of philosophy, and I must confess that I have no idea what is meant by an enlightenment understanding of truth! That I do not "equate truth with historical fact" should be obvious in view of my strong emphasis upon the truth and nonliterality of myth.

Making Paul's theology "dependent on the historicity of a literal Adam" is said to "tie Christian belief to unnecessarily improbable and even problematic assumptions" (p. 243). That allegation not only unjustifiably assumes that Paul's theology is not in fact tied to such problematic assumptions, but also presumes that such assumptions are problematic—which is addressed in my answer to the second question.

In response to question two, I argue on the basis of a wide range of "archaeological signatures" of modern cognitive behavior among not only early *Homo sapiens* but also Neanderthals, that a human founding pair would have had to be located prior to the divergence of Neanderthals and *Homo sapiens*. This suggests that Adam and Eve belonged to the most recent common ancestor of these two species, *Homo heidelbergensis*. It is striking that the reviewers omit any mention of these fascinating and remarkable archaeological signatures that support my contention. This omission is made all the worse by their disparaging remarks concerning the cognitive capacity of Neanderthals.

Although, *pace* the reviewers, I am not seeking the genetic Adam and Eve but rather the genealogical Adam and Eve, nevertheless I affirm the relevance and vital importance of population genetics for my quest. My argument is simply that the data of population genetics do not rule out a founding human pair if they lived earlier than 500kya; this is consistent with my hypothesis.

The reviewers seem to ascribe to me the bizarre position that Adam and Eve "completely replaced all other *H. heidelbergensis* members without any death: people died without passing on their alleles; that is what descending from only two people living in a giant population means" (p. 244). I do not understand the view that they ascribe to me. In the book, I hypothesize that Adam and Eve had many nonhuman contemporaries among the population from which they emerged as the first humans. So, all the envisioned factors that actually led to the dispersal of *Homo heidelbergensis* throughout the world remain in place. Moreover, I suggest that it is plausible that, as the only human persons, Adam and Eve's descendants would naturally prefer one another's company to that of beasts and therefore naturally tend to self-isolate from their nonhuman contemporaries, thereby abetting dispersal.

Sincerely,
William Lane Craig

Review Authors Reply to Book Author

Craig's response to our review of his book *In Quest of the Historical Adam* (Sara M. Koenig and Cara M. Wall-Scheffler, "Discussions about Dispersals: Questions Rising from the Search for Historical Adam," *PSCF* 74, no. 4 [2022]: 242–45) strikes us as representative of the intense value of a liberal arts education. There is nothing so important in this world as understanding the frames of reference, the management of evidence, and the sensitivity of each discipline to vocabulary and word choice: how many of us have toiled through teaching introductory courses which seek to win undergraduates over to the specificity of word choice that allows for in-group, specialist conversations to persist? His concerns that we misunderstood his ideas were framed with examples that seemed, in fact, to misunderstand what we wrote. Potentially, this happened because certain words mean something different when philosophers use them than when biblical scholars and biological anthropologists use those same words.

The first case in point would be to suggest that we made "disparaging" comments about Neanderthals by mentioning that they had significantly better night vision than we have and a very clever form of locomotion that probably prevented back pain. That they did not have an enlarged frontal cortex is a fact; this did not stop them from being the dominant species in Europe for hundreds of thousands of years and from doing many things extremely well. Not being the same as us is not disparaging (at least not to this biological anthropologist and this biblical scholar). In fact, it is part of the wonder of creation that incredible bio***diversity*** exists.

A second example is something Craig admitted and confessed, that he had no idea what was meant by "an enlightenment understanding of truth." We were referring to the enlightenment's emphasis on scientific rationality, which could hinder understandings of truth as myth. In response to Craig's statement in his response, "That I do not 'equate truth with historical fact' should be obvious in view of my strong emphasis upon the truth and nonliterality of myth," we did acknowledge our surprise in the original review, that while he does seem to allow that "someone can read the narratives in Genesis in nonliteral ways," yet "he insists that the Pauline texts must be read literally" (p. 243). Therefore, he seems to be suggesting that unless something is "literal" it cannot be true; this is an enlightenment understanding.

Ultimately, we want to reiterate that we understand how people believe in the historical or genealogical Adam, and for those people, this book will be helpful. Other reviews of and responses to Craig's work indicate as much. We do not think that a belief in historical Eve and Adam is necessary for a deep, fruitful, biblical faith and discipleship. We further suggest that this book did not push biblical studies or paleoanthropology forward as disciplines. The ideas put forth about Romans 5 have been discussed previously in many places (including in this journal), and the difficulties of a behavioral ancestor between *H. sapiens* and *H. neanderthalensis* was dealt with in response to hypotheses about *H. helmei*. Currently, paleoanthropology is more interested in the diversity of hominin species, convergence, and the complexity of small changes in development making large changes in morphology possible for specialized niche adaptations. We look forward to a book that seeks to ask testable, theological questions of God's creative mechanisms within the contexts of forward-thinking biology and spirit-driven theology.

Respectfully,
Sara M. Koenig and Cara M. Wall-Scheffler ☼

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

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